60455860

CONTROL DATA

CDC® 7155 DISK STORAGE SUBSYSTEM

7155 DISK STORAGE CONTROLLER

844–4X DOUBLE DENSITY DISK STORAGE UNIT

885 DISK STORAGE UNIT

REFERENCE MANUAL

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New features, as well as changes, deletions, and additions to information in this manual, are indicated by bars in the margins or by a dot near the page number if the entire page is affected. A bar by the page number indicates pagination rather than content has changed.

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PREFACE

This manual contains operation and programming information for the CDC® 7155 Disk Storage Subsystem, which provides mass storage for large Control Data computers. The manual is written for computer operators and for system programmers who generate or maintain peripheral processor-resident programs that drive the 7155 subsystem.

The following Control Data products are used in 7155 subsystems.

Product	Nomenclature
7155-1	Single-access disk storage controller
7155-11	Single-access disk storage controller
7155-12	Two-access disk storage controller
7155-13	Three-access disk storage controller
7155-14	Four-access disk storage controller
844-41	Two-channel disk storage unit
844-44	Four-channel disk storage unit
883-60	Disk pack for 844-4X
885-11	Single-channel disk storage unit
885-12	Two-channel disk storage unit
10396-1	Second channel for 885-11
10397-1	Additional access for 7155-1/11/12/13
10398-1	844-4X interface for 7155-1/11/12/13/14
10399-1	Second 885 interface for 7155-1/11/12/13/14
65290	Large sector hardware option 7155-1/2/3/4

RELATED PUBLICATIONS

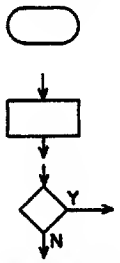
The following manuals contain information applicable to the 7155 subsystem.

Control Data Publication	Publication Number
CYBER 70 Models 72/73/74, 6000 Computer Systems Input/Output Specifications	60352500
CYBER 170 Models 171 through 175 Computer Systems Hardware Reference Manual	60420000
7155 Operator Maintenance Guide	60456650
FA211 Disk Controller Hardware Maintenance Manual†	60455690

CONVENTIONS

The following conventions are used in this manual.

- All numbers are decimal unless another base is indicated.
- Bits are numbered from right to left, beginning with 0. Thus, the number of a bit indicates its power of two.
- Flowchart symbols are:



Entry/exit point

Processing

Decision; Y represents yes and N represents no

- Logical zero and logical one are abbreviated 0 and 1, respectively.

DISCLAIMER

The 7155 subsystem is intended for use only as described in this manual. Control Data cannot be responsible for the proper functioning of undescribed functions or parameters.

†The controller hardware maintenance manual references other hardware maintenance manuals associated with the 7155 subsystem.

WARNING

This equipment generates, uses and can radiate radio frequency energy and if not installed and used in accordance with the instructions manual, will cause interference to radio communications. This equipment has been tested with a Class A computing devices and has been found to comply with Part 15 of the FCC Rules which are designed to provide reasonable protection against such interference. Operation of this equipment in a residential area may cause unacceptable interference in which case the user at his own expense will be required to take whatever measures may be required to correct the interference.

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The 7155 Disk Storage Subsystem provides random-access mass storage for CDC 6000 series, CDC CYBER 70 model 72, 73, 74 and CDC CYBER 170 series computers. A peripheral processor (PP) channel provides the computer/subsystem connection. Besides incorporating features of the 7154 Disk Storage Subsystem, the 7155 subsystem also:

- Enables use of high-capacity, high-speed, fixed media CDC 885 Disk Storage Units along with removeable-media CDC 844-4X Double Density Disk Storage Units.
- Allows data to be transferred between PP and 7155 Disk Storage Controller (controller) at the maximum PP channel rate.
- Incorporates simplified design and enhanced diagnostic capability to improve subsystem reliability.

This section provides hardware descriptions, configuration examples, storage theory, and functional specifications applicable to the 7155 subsystem. Refer to the glossary (appendix A) for definitions of terms used in this manual.

HARDWARE

Figures 1-1 through 1-3 show the controller and disk storage units used in 7155 subsystems. A subsystem may contain one or more controllers, one to eight 844-4X Double Density Disk Storage Units (844 drives) per controller, and one to eight 885 Disk Storage Units per controller. Each 885 Disk Storage Unit contains two 885 drives, so two to 16 885 drives may attach to one controller.

NOTE

Within this manual, the term drive refers to either type of drive. The specific terms 844 drive and 885 drive appear in statements that apply to one type of drive only.

CONTROLLER

The controller is a programmable device that provides overall subsystem control. Before use, the controller must be initialized as described in section 2. Figure 1-4 shows the following controller elements.

Element	Description
PP access	Provides connection between one PP channel and access control.
Access control	Determines PP access to be connected. Establishes data path between connected access and buffer. Establishes control path between connected access and processor channels.
Processor	Executes controlware to provide functions described in section 3. Controlware includes code stored in read-only memory (ROM) portion and random access memory (RAM) portion of processor memory. Refer to controller hardware maintenance manual listed in the preface for processor instruction descriptions.
Processor memory†	Contains 7K or 9K words of 16-bit-per-word storage. Includes 1K ROM and 4K RAM for controlware storage, and 2K or 4K buffer†† for data transfer operations.
Processor channels	Provide control/status paths between processor and access control and between processor and data format/error correction code (ECC) control. Also provide block transfer path for autoload/autodump operations.
Data format/ECC control	Generates/detects write/read and cyclic redundancy code (CRC) patterns.
885 drive interface	Provides connection between data format/ECC control and two to eight 885 drives.
844 drive interface	Provides connection between data format/ECC control and one to eight 844 drives.

The basic controller has one PP access and a drive interface that accommodates two to eight 885 drives. The following three options allow connection of additional PP channels and drives to the controller. The last option allows NOS/VE to run on an FA211-A.

†1 K = 1024

††The 7155-1 Disk Storage Controller has a 2K buffer and the 7155-11/12/13/14 Disk Storage Controllers have a 4K buffer.

Standard Option	Description
10397-1	Adds one PP access to controller. Maximum number of PP access per controller is four.
10398-1	Expands drive interface to allow connection of one to eight 844 drives.
10399-1	Expands drive interface to allow connection of additional two to eight 885 drives.
65290-1	Allows the FA211-A to run serial large sector mode on 885 drives.

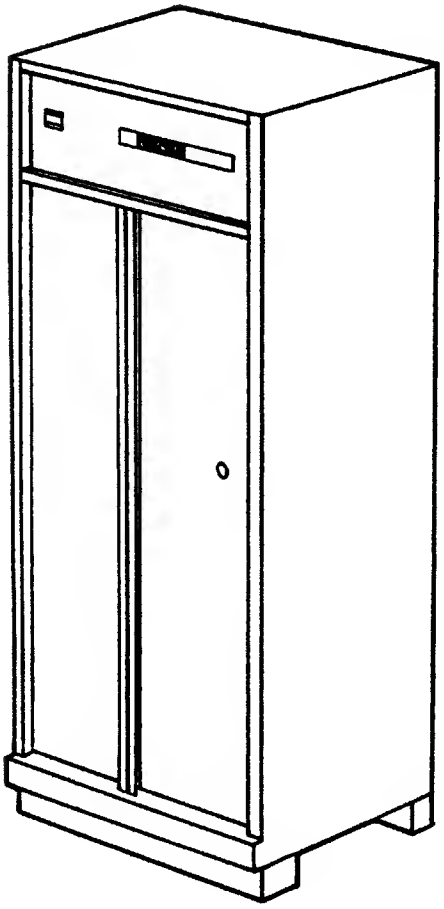


Figure 1-1. 7155 Disk Storage Controller

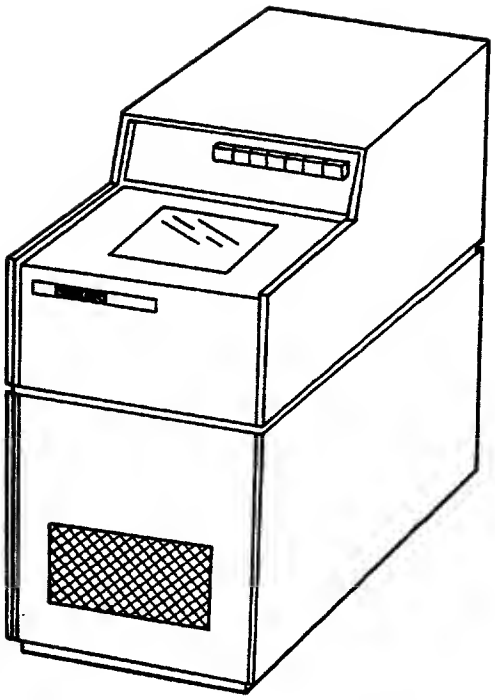


Figure 1-2. 844-4x Double Density Disk Storage Unit

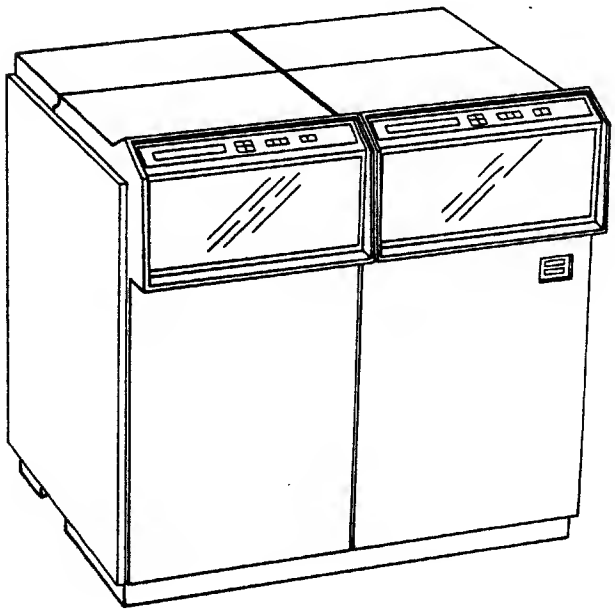
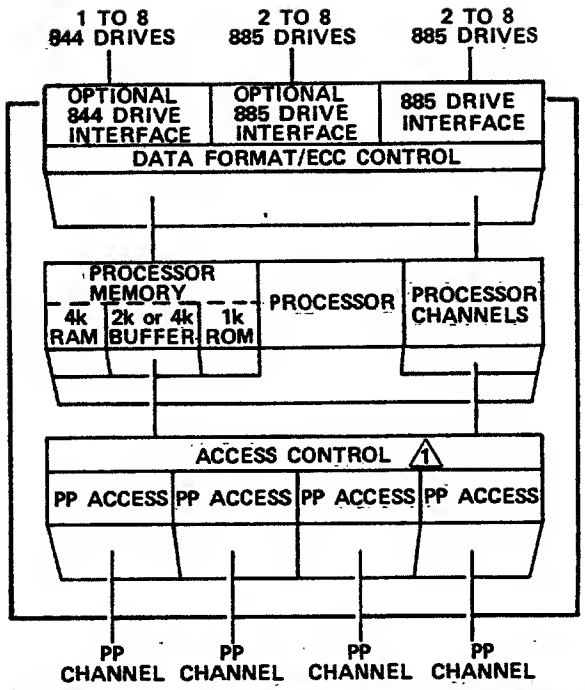


Figure 1-3. 885 Disk Storage Unit



1 The controller has from one to four PP accesses, depending upon the model and options. Refer to the preface for product information.

Figure 1-4. Controller Functional Elements

DRIVES

Although they differ in physical appearance, data transfer rates, and data capacity, the 844 drive and the 885 drive each contain the functional elements shown in figure 1-5 and described briefly as follows:

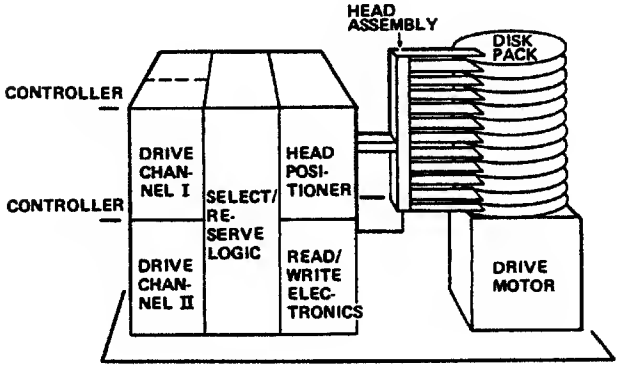


Figure 1-5. Drive Functional Elements

Element	Description
Drive channel	Connects select/reserve logic with one set of controller/drive interface lines. 844-41, 844-44, 885-11, and 885-12 drives have two, four, one, and two drive channels each, respectively. Standard option 10396-1 adds second drive channel to each drive in 885-11 cabinet.
Select/reserve logic	Determines drive channel to be connected. Controls head positioner and read/write electronics in response to controller commands.
Head positioner	Positions head assembly to disk pack cylinder specified by controller commands.
Read/write electronics	Translates digital data waveforms to write current and read current to digital data waveforms.
Head assembly†	Contains several read/write heads, each of which translates current to magnetic flux changes on rotating disk pack, and vice versa.
Disk pack†	Provides surfaces for recording data as magnetic flux changes.
Drive motor	Rotates disk pack.

CONFIGURATIONS

Figures 1-6 and 1-7 show minimum and large 7155 subsystem configurations, respectively.

STORAGE THEORY

All rotating magnetic data storage devices apply the principle that electric current flowing near a recording medium changes the magnetic flux of the medium. Conversely, when motion exists between a conductor and a nearby medium containing magnetic flux changes, current flows in the conductor.

For a drive, the conductor is a read/write head and the medium is a disk pack. The drive's read/write electronics convert data to write current, and extract data from detected read current.

† 885 drive combines head assembly and disk pack in unit called head/disk assembly (HDA).

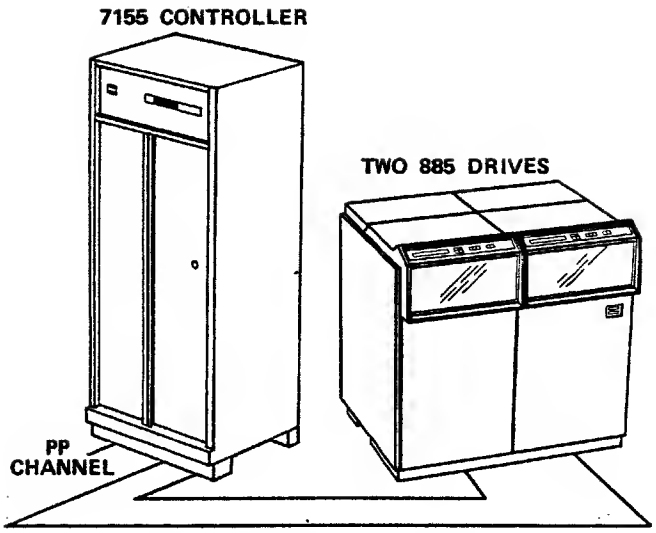


Figure 1-6. Minimum 7155 Subsystem

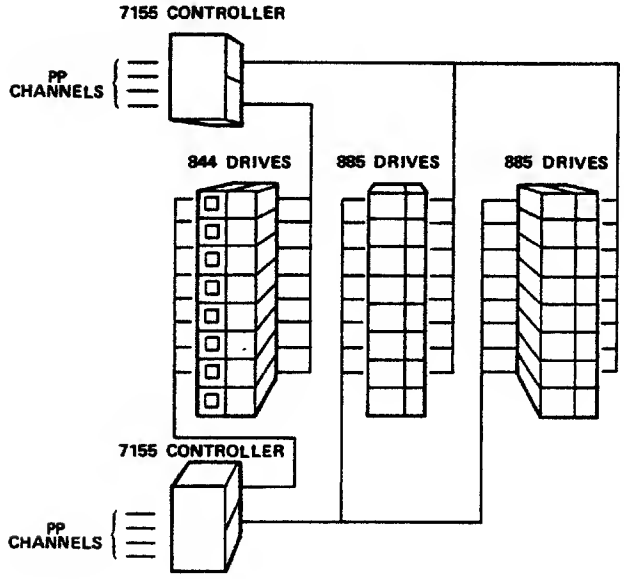


Figure 1-7. Large 7155 Subsystem

DATA ORGANIZATION

As a disk pack rotates, current-induced flux changes trace a circular path around the disk. These flux changes are grouped into sectors, tracks, and cylinders.

- A sector is an arc of contiguous flux changes traced by a head.
- A track is the circle of flux changes traced by a head at one head position.
- A cylinder is all of the tracks at one head position.

A complete disk address consists of a cylinder number, a track number, and a sector number. Figure 1-8 shows the relationship of sector, track, and cylinder.

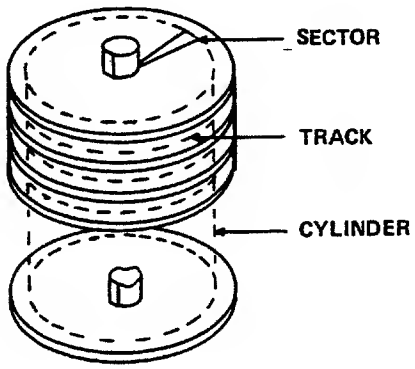


Figure 1-8. Data Organization

SECTOR FORMAT

Figure 1-9 shows the fields within 844 and 885 sectors. Table 3-5 lists the number of bits in each field. Field descriptions are as follows.

Field	Description
Sync pattern/byte 1	Synchronizes drive read electronics with first bit of address field.
Address field/checkword	Provides disk address and flaw information for sector. Checkword is code used to detect (and in some cases correct) error in preceding field.
Sync pattern/byte 2	Synchronizes drive read electronics with first bit of data field.
Data field/checkword/ end-of-record byte	Contains 322 (344 in 885 Large Sector Mode) 12-bit words of data, associated checkword, and end-of-record byte.
Tolerance gap	Accommodates minor head displacement and satisfies controlware overhead requirements.

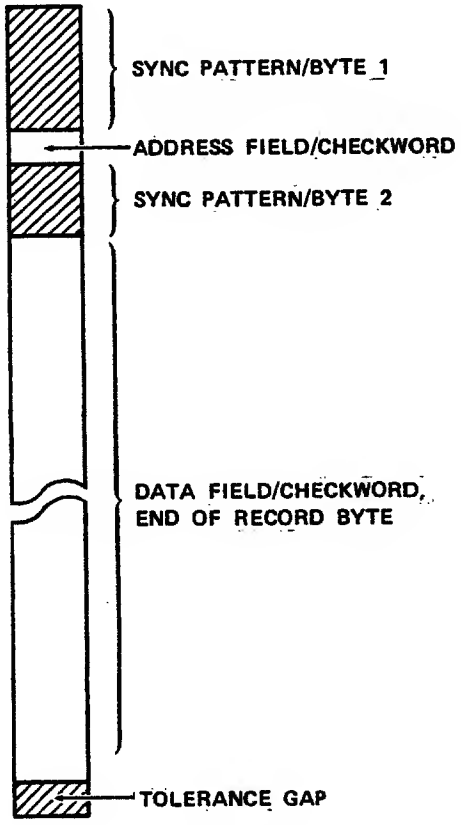


Figure 1-9. Sector Format

INTERLACING

High subsystem data transfer rates may result in less time between consecutive sectors than is required for PP program overhead. To prevent lost disk revolutions caused by this type of conflict, the 7155 subsystem retains the variable interlace capability of earlier subsystems.

Interlace is the ratio of number of sectors, processed to number of sectors actually passing the head. Thus, a 1:1 interlace operation processes every sector passing the head and a 2:1 interlace operation processes every other sector passing the head.

For a given cylinder, a 2:1 interlace operation processes all even-numbered sectors before processing odd-numbered sectors.

The seek function preceding an operation establishes the interlace for the operation. Gap sector functions issued during an operation can change the interlace to 3:1 (from 1:1) or 4:1 (from 2:1) on a sector-to-sector basis.

All interlaces except 1:1 require more than one disk revolution to process all sectors on a track.

TYPICAL OPERATION

A PP performs an operation (such as a read or a write) by issuing a series of functions to the controller. The following sequence shows functions used by a PP during a typical read operation.

Activity	Function(s)
Connect controller and check subsystem status	General status, detailed status
Establish interlace, reserve drive, and initiate head positioning	Seek
Wait for drive to become on-cylinder	General status, seek
Transfer data from drive to controller to PP	Read
Check for read errors	General status, detailed status
Release controller and drive	Operation complete

FUNCTIONAL SPECIFICATIONS

Tables 1-1 through 1-4 provide data capacities and functional specifications for 844 and 885 drives. The only functional specification applicable to the controller is the maximum transfer rate between the controller and a PP, which is 5.88×10^6 12-bit words/second. Although the controller is able to transfer data up to 5.88 MHz, a PP is able to transfer data at only 1 MHz or 2 MHz.

TABLE 1-1. 844 DRIVE DATA CAPACITY †

Number of	Per			
	Sector	Track	Cylinder	Disk Pack
12-bit words	322	7 728	146 832	120 402 240
Sectors	1	24	456	373 920
Tracks	-	1	19	15 580
Cylinders	-	-	1	820

TABLE 1-2. 885 DRIVE DATA CAPACITY †

Number of	Per			
	Sector	Track	Cylinder	Disk Pack
12-bit words	322	10 304	412 160	346 626 560
Sectors	1	32	1 280	1 076 480
Tracks	-	1	40	33 640
Cylinders	-	-	1	841

TABLE 1-3. 885 LARGE SECTOR MODE DRIVE DATA CAPACITY †

Number of	Per			
	Sector	Track	Cylinder	Disk Pack
12-bit words	1376	11 008	440 320	370 309 120
Sectors	1	8	320	269 120
Tracks	-	-	40	33 640
Cylinders	-	-	-	841

TABLE 1-4. DRIVE FUNCTIONAL SPECIFICATIONS

Characteristic	Value	
	844 Drive	885 Drive
Maximum seek time	55 milliseconds	50 milliseconds
Average seek time	30 milliseconds	25 milliseconds
Cylinder-to-cylinder seek time	10 milliseconds	10 milliseconds
Nominal disk revolution time	16.7 milliseconds	16.7 milliseconds
Transfer rate	6.45×10^6 bits/second	9.58×10^6 bits/second

Table 1-5 lists average data transfer rates for one or more tracks of data. The 1:1 interlace rates are determined by dividing track data capacity by the nominal disk revolution time. Rates for 2:1 interlace are half those for 1:1 interlace since only half of a track's data transfers per revolution during a 2:1 interlace transfer.

TABLE 1-5. AVERAGE DATA TRANSFER RATES

Drive	Interlace	Average Data Transfer Rate (12-bit words/second)
844	1:1	4.63×10^5
	2:1	2.31×10^5
885	1:1	6.17×10^5
	2:1	3.09×10^5

† Does not include cylinders reserved for maintenance purposes.

This section describes operator switches/indicators for each subsystem equipment and provides procedures for typical operator tasks.

SWITCHES/INDICATORS

Figures 2-1 through 2-3 show the locations of subsystem operator switches/indicators. Tables 2-1 through 2-3 describe switch/indicator functions.

OPERATING PROCEDURES

Although subsystem operator intervention is infrequent and determined by site configuration, the following paragraphs provide general guidelines for typical operator tasks.

SUBSYSTEM POWER CONTROL

Each controller and drive contains power sequence circuitry that regulates initial subsystem electrical load. This circuitry allows power feeding the entire subsystem to be controlled from a single power control box. At installation time, a customer engineer performs the cable routing and switch setting required for power sequencing. Thereafter, the operator normally controls subsystem power from the power control box.

Once power has been applied, the subsystem is ready for operation when the READY indicator lights on the last drive to receive power. The operator can turn a single drive off or on with the drive's START switch. Removing logic power from a controller that is providing power sequencing to a group of drives also removes power from each drive whose LOCAL/REMOTE switch (a customer engineer switch located inside the drive cabinet) is set to REMOTE.

CONTROLLER INITIALIZATION

A controller must be autoloaded with controlware before the controller can execute the complete function set described in section 3. The following functions reside permanently in the ROM portion of processor memory to enable autoloading.

0012_8	General status
0042_8	Clear connected access
$01NN_8$	Autoload from disk
0414_8	Autoload from PP

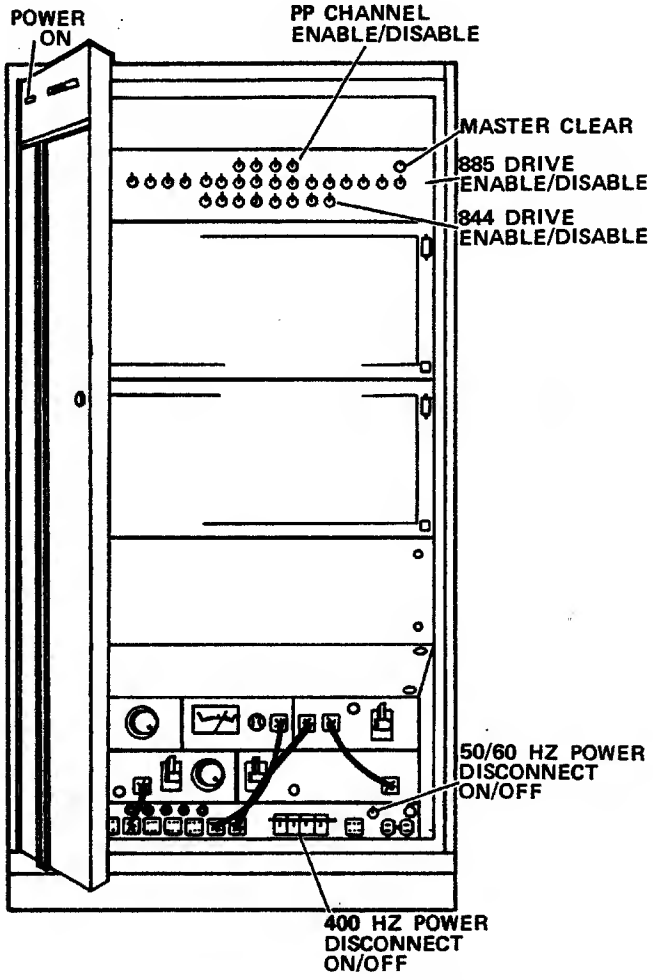


Figure 2-1. Controller Switch/Indicator Locations

Although all controller autoload procedures rely on one or more of these functions, the exact procedure used depends upon site operating procedures, the operating system in use, computer system configuration, and whether or not the computer system is running. Refer to the appropriate operating system installation handbook for controller autoload procedures that Control Data recommends.

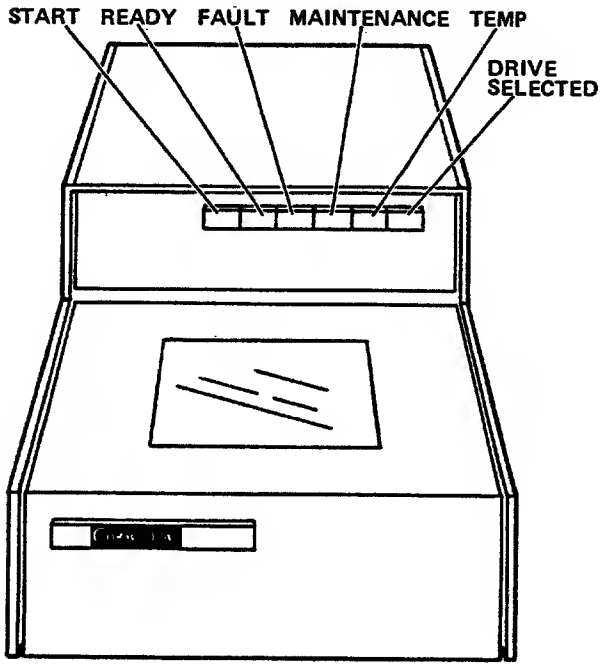


Figure 2-2. 844 Drive Switch/Indicator Locations

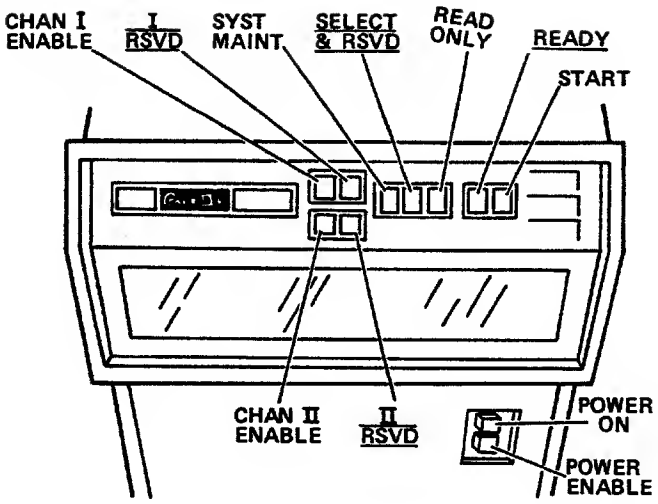


Figure 2-3. 885 Drive Switch/Indicator Locations

DISK PACK EXCHANGE

Use the following procedure to exchange the disk pack of an 844 drive.

1. If START switch/indicator is lighted, press it and wait for disk pack to stop.
2. Press main cover latch and lift main cover.
3. Place disk pack cover over disk pack. Turn cover counterclockwise until spindle clicks. Lift cover and disk pack from drive.
4. Place new cover and disk pack on spindle. Turn cover clockwise until it stops. Lift cover from drive.
5. Close main cover, ensuring that it latches.
6. Press START switch/indicator. Drive is ready for operation when READY indicator lights.

TABLE 2-1. CONTROLLER SWITCHES/INDICATORS

Name	Description	Function
POWER ON	Indicator	Lights when power is applied to controller.
PP CHANNEL ENABLE/DISABLE	Toggle switches (4)	Enables/disables communication between controller and PP channel attached to access associated with switch.
MASTER CLEAR	Pushbutton switch	Clears controller logic and connected access and forces processor memory address to $20\,000_8$.
885 DRIVE ENABLE/DISABLE	Toggle switches (16)	Enables/disables communication between controller and 885 drive attached to connector associated with switch.
844 DRIVE ENABLE/DISABLE	Toggle switches (8)	Enables/disables communication between controller and 844 drive attached to connectors associated with switch.
50/60 HZ POWER DISCONNECT ON/OFF	Toggle switch	ON: Applies power to blower. OFF: Removes power from blower.
400 HZ POWER DISCONNECT ON/OFF	Toggle switch	ON: Applies power to controller logic. OFF: Removes power from controller logic.

TABLE 2-2. 844 DRIVE SWITCHES/INDICATORS

Name	Description	Function
START	Switch/indicator	Applies/removes power to/from drive logic and drive motor. Lights when power is applied.
READY	Indicator	Lights when disk pack reaches operating speed and heads are loaded.
FAULT	Switch/indicator	Clears drive fault status. Lights when drive fault status is active.
MAINTENANCE	Indicator	Lights when drive power is not sequenced by controller.
TEMP	Indicator	Lights when over-temperature condition exists within drive.
None	Indicator	Lights when drive is selected by controller. Customer may elect to apply numbered lens to indicator.

TABLE 2-3. 885 DRIVE SWITCHES/INDICATORS

Name	Description	Function
CHAN I ENABLE	Switch/indicator	Enables/disables communication between drive and controller attached to associated drive channel. Lights when communication is enabled.
CHAN II ENABLE	Switch/indicator	Enables/disables communication between drive and controller attached to associated drive channel. Lights when communication is enabled.
I RSVD	Indicator	Lights when associated drive channel is reserved by controller.
II RSVD	Indicator	Lights when associated drive channel is reserved by controller.
SYST MAINT	Switch/indicator	Maintenance use only. Enables/disables fault checking and manual seek tests. Lights when fault checking and manual seeks are enabled.
SELECT & RSVD	Indicator	Lights when reserved drive channel is active.
READ ONLY	Switch/indicator	Disables/enables write logic within drive. Lights when write logic is disabled.
READY	Indicator	Lights when disk pack reaches operating speed and drive is on track.
START	Switch/indicator	Applies/removes power to/from drive motor. Lights when power is applied.
POWER ENABLE	Switch/indicator	Enables/disables cabinet power input. Lights when power is enabled.
POWER ON	Switch/indicator	Maintenance use only. Applies power to both drives, provided LOCAL/REMOTE switch (inside cabinet) is set to LOCAL. Lights when power is applied.

This section covers some general topics of interest to the programmer, defines function codes, and provides error recovery sequences. Unless otherwise indicated, all 4-digit numbers referenced in this section are octal.

GENERAL CONSIDERATIONS

The programmer should be familiar with the following information before working on 7155-related PP programs.

PP TYPE

PPs attached to a controller may operate at either 1 MHz or 2 MHz. A PP channel without parity must attach to a PP access having channel parity disabled. Disabling channel parity is a customer engineering task performed during subsystem installation.

EQUIPMENT CODE

Since a controller is the only device on a channel, no equipment select code is required and all 12 bits are used for function selection.

ACCESS CONNECTION

When no accesses are connected, the controller connects to the first access receiving a function. As long as one access is connected, the controller ignores all functions received on other accesses except for 0012 (general status) and 0042 (clear connected access) functions, which are processed normally. When one access is connected and an unconnnected access receives a general status function, the status word returned is 2000.

Access connection clears when:

- The connected access receives a 0010 (operation complete) function.
- Any access receives a 0042 (clear connected access) function.
- A power on or pushbutton master clear occurs.
- A deadstart master clear occurs on the connected access. The deadstart master clear also releases all drives, provided controlware instruction and buffer tests (which precede drive release) execute without error.

CONTROLWARE

Controlware used with the controller includes permanently resident code (ROM controlware) and MA721 code loaded at autoload time (RAM controlware). ROM controlware includes a processor instruction test, a buffer test, a drive release routine, the function idle loop, and routines to process 0012 (general status), 0042 (clear connected access), 0057 (echo one word), 0061 (autodump), 0062 (manipulate processor), 0063 (input display data), 01NN (autoload from disk), and 0414 (autoload from PP) functions. RAM controlware includes routines to process the remaining functions.

Figure 3-1 shows ROM controlware execution following a power on, pushbutton, or deadstart master clear.

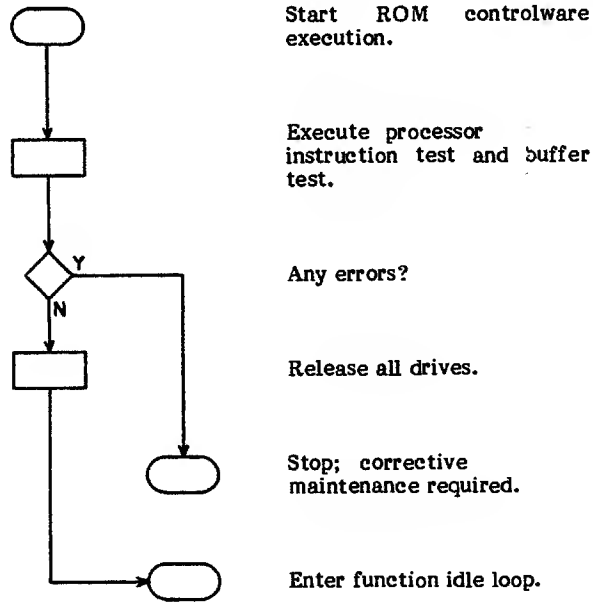


Figure 3-1. Initial ROM Controlware Execution

PACK DATA

Appendix D provides locations and format descriptions for disk sectors that contain factory-recorded manufacturing data, flaw data, and defective sector data.

DEADMAN TIMER

For disk read/write-type functions and 0043/0044 (buffer read/write) functions, the controller deactivates the PP channel when an error occurs that would prevent successful completion of the function. However, for other functions that transfer data, status, or parameters between the controller and the PP, the controller uses a deadman timer. This timer monitors the connected PP channel for a hung condition. When it detects that an active channel has not transferred a word for 4.5 ± 1.5 seconds, the timer deactivates the channel. Note 1 of table 3-1 identifies functions for which the controller is able to provide deadman timeout status.

PARITY ERRORS

Parity error types and corresponding detection/processing procedures (for PPs with channel parity) are as follows:

Error Type	Detection/Processing Procedure
Parity error on function	Controller does not respond to function having parity error, but instead clears parity error status and waits for next function. PP must time out each function to avoid possible channel hang. After detecting function time out, PP should deactivate channel; resend function; and, if parity errors continue, abort operation.
Parity error on parameter or data output	After completing parameter output, PP must issue 0012 (general status) function,† after which controller prepares status and clears parity error condition. Refer to the other two error types if parity error occurs during general or detailed status request. General status is 5000 and extended detailed status (word 16, bit 6) reflects error condition. Refer to the other two error types if parity error occurs during general or detailed status request. General status is 5000 and extended detailed status (word 16, bit 6) reflects error condition. PP should reissue function; reoutput parameter(s) or data; and, if parity errors continue, abort operation.
Parity error on input	After completing input, PP should test appropriate bit in status and control register before issuing next function. Since controller cannot detect parity error on PP input, general status shows only what happened within subsystem. Suggested PP actions are: • Reissue function and reinput data or status. • Reseek sector and reread sector or block of sectors. • Abort operation if parity errors continue.
Program memory parity error	All functions other than 414 and 1UU will time out under this condition. To properly report and recover from this error the PP should: • Issue a zero word autoload to clear the hang. • Issue the autodump function to sweep memory. Discard the dump data. • Issue the input processor status function. Input 20 words. If word 1 indicates a RAM parity error, log the error and continue to step 4. • If the timeout was on a write function, the WBDF cell in controlware will say the type of write error it was and will help identify the disk recovery address.†† If this is a write buffer to disk error and word 20 in step 3 indicates a model B controller, read the subsystem data buffer. A write buffer to disk error will not be recoverable in a model A controller. • Download controlware via the interlock autoload function and retry the operation.

INPUT/OUTPUT RULES

The following rules govern PP channel use.

- All functions must have a timeout limit (1 second is recommended) to prevent subsystem failures and errors from hanging channel.
- PP must activate channel before transferring parameters or data.
- PP must deactivate channel following output of parameters or data.
- Controller deactivates channel following PP input or when disk data transfer error prevents PP input/output from completing normally.
- Controller deactivates channel when error conditions leaves controller connected and channel active for 4.5 ± 1.5 seconds.

† 0062 (manipulate processor) function does not have to be followed by 0012 (general status) function.

†† WBDF is location 321 of program memory and may be examined via the 62 and 63 functions. A zero in WBDF indicates a buffer to disk error (reference detailed status word 13 bit 11). This cell should be used rather than detailed status because the latter cannot be guaranteed under RAM parity conditions.

LOGICAL SECTORS

Unless otherwise specified, this manual identifies disk sectors by their logical (as opposed to physical) sector numbers. For 844 drives, logical and physical sector numbers are identical and range from 0 through 23. For most tracks on an 885 drive, logical and physical sector numbers are identical and range from 0 to 31.

Controller detailed status (word 7, bits 11 through 4) and operating system messages always use logical sector numbers to identify 885 sectors. However, factory and utility maps (and in some cases, the controller) use physical sector numbers to identify 885 sectors. Proper use of the format pack (0016), return cylinder addresses (0017), and scan cylinder addresses (0047) functions requires knowledge of the relationship between logical and physical 885 sectors.

The only time the physical and logical sector numbers for an 885 sector differ is when the track containing the sector also contains one or more skipped sectors. A skipped sector is one whose address and data fields have been zero-filled to avoid detection by the controller. When physical sector n (where n ranges from 0 to 31) is skipped on an 885 track, each logical sector after physical sector n has a smaller number than its corresponding physical sector. Figure 3-1.1 shows the relationship between physical and logical sector numbers for tracks with zero, one, or two skipped sectors. A track with more than two skipped sectors contains a track flaw bit in the address field of each logical sector and is unused. Figure 3-1.2 shows how to convert a logical 885 sector number to a physical sector number.

P00	P01	P02	P03		P29	P30	P31	P32	P33
L00	L01	L02	L03	...	L29	L30	L31	UUU	UUU

Situation A: No defective sectors; sectors 32 and 33 unused.

P00	P01	P02	P03		P29	P30	P31	P32	P33
L00	L01	XXX	L02	...	L28	L29	L30	L31	UUU

Situation B: One defective sector; physical sector 02 skipped, physical sector 33 unused.

P00	P01	P02	P03		P29	P30	P31	P32	P33
L00	L01	XXX	L02	...	L28	XXX	L29	L30	L31

Situation C: Two defective sectors; physical sectors 02 and 30 skipped.

Notes:

1. Lnn = Logical sector number
   Pnn = Physical sector number
   UUU = Unused, formatted sector
   XXX = Skipped, zero-filled sector

2. When it formats multiple tracks, the format pack (0016) function places logical sector numbers 32 and 33 in the second to last full sector and last full sector, respectively, of each track. (Physical sector 34, mentioned in the return drive address (0017) function, is actually a 93-microsecond tolerance gap that is not used for data storage.) Since 7155 controlware normally processes only the first 32 logical sectors on a track, logical sectors 32 and 33 are never encountered in normal processing, and need not be zero-filled (skipped) if defective.

Figure 3-1.1. 885 Sector Numbering

On a track with 32 logical sectors, an 885 physical sector number may be the same as, one greater than, or two greater than its corresponding logical sector number. The relationship between the two numbers depends upon whether there are any skipped sectors between the start of the track and the sector to be skipped. To determine the value to use for the physical sector number of a sector to be skipped, obtain values P, L and then identify the P/L relationship that applies to your case. P and L are defined as follows:

P Physical sector number of skipped sector in same track as sector to be skipped (from utility map).

L Logical sector number of defective sector (from operating system).

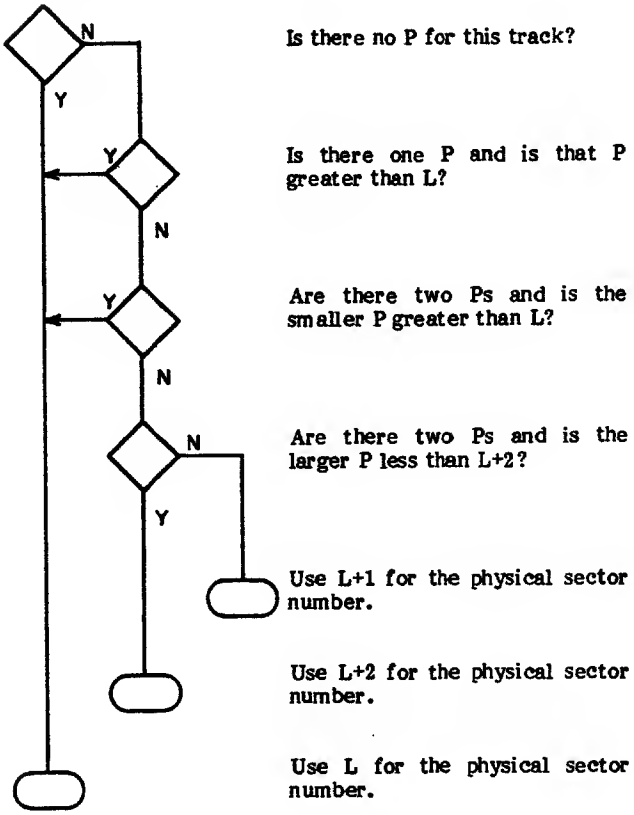


Figure 3-1.2. Logical-to-Physical 885 Sector Conversion

FUNCTIONS

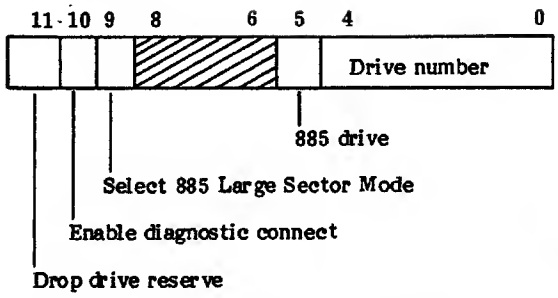
Table 3-1 lists functions to which the controller responds and appendix B provides function timing information. The following paragraphs describe each function.

0000 - CONNECT

Reserves drive without initiating head movement. Drive remains reserved until PP issues 0010 (operation complete), 0015 (drop seeks), or 0020 (drive release) function.

Bit 11 of connect parameter drops drive reserve held by another controller. Parameter bit 10 is for diagnostic use only. Parameter bit 5 indicates 885 drive.

Parameter format:



Legal drive numbers (bits 0 through 5) are:

844	0 through 7
885	40_8 through 57_8

NOTE

If bit 11 fails to drop 844 drive reserve, issue deadstart master clear or press controller MASTER CLEAR button.

TABLE 3-1. SUBSYSTEM FUNCTIONS

Octal Code	Function	Words Output	Words Input	General Status Required
0000	Connect (1)	1		Yes
0001	Seek, 1:1 interlace (1)	4		Yes
0002	Seek, 2:1 interlace (1)	4		Yes
0004	Read		(6)	Yes
0005	Write	(6)		Yes 2
0006	Write verify	(6)		Yes 2
0007	Read checkword			Yes
0010	Operation complete			No
0011	Disable drive reserve			No
0012	General status		1	No
0013	Detailed status		12	No
0014	Continue	(6)(3)	(6)(4)	Yes
0015	Drop seeks			No
0016	Format pack (1)	7		Yes
0017	Return drive address		3	No
0020	Drive release			No
0021	Return cylinder address		1	No
0022	Set/clear flaw (1)	1		Yes
0023	Extended detailed status		20	No
0024	Read gap sector		(6)	Yes
0025	Write gap sector	(6)		Yes (2)
0026	Write verify gap sector	(6)		Yes (2)
0027	Read checkword gap sector			Yes
0030	Read factory data		322	Yes
0031	Read utility map		322	Yes
0032	Block transfer buffer read		322	No
0033	Block transfer buffer write (1)	322		Yes
0034	Read protected sector		322	Yes
0035	Write last sector	(6)		Yes
0036	Write verify last sector	(6)		Yes
0037	Write protected sector	322		Yes
0040	Read short		319 (5)	Yes
0041	Select strobe and offset (1)	1		Yes
0042	Clear connected access			No
0043	Buffer read		322	Yes
0044	Buffer write	322		Yes
0046	Write buffer to disk			Yes
0047	Scan cylinder addresses			Yes
0050	Output on processor channel (1)	3		Yes
0051	Execute control word sequence (1)	49		Yes

NOTES

(1) When PP channel deadman timer expires during this function, controller prepares 5000 general status and sets deadman timeout bit (word 17, bit 3) in detailed status.

(2) Except when executing this function at 2:1 interlace on 844 drive, controller returns general status before transferring data from buffer to disk. If error occurs during buffer-to-disk transfer, controller responds only to 0012 (general status) function. This ensures that buffer-to-disk errors do not go undetected.

(3) Following write-type function only.

(4) Following read-type function only.

(5) 844 only; use 318 for 885; 1360 for 885 large sector.

(6) 322 words for small sector, 1376 words for large sector 885.

TABLE 3-1. SUBSYSTEM FUNCTIONS (Contd)

Octal Code	Function	Words Output	General Words Input	Status Required	Octal Code	Function	Words Output	General Words Input	Status Required
0052	Input processor channel status		32	No	0063	Input display data		64	No
0053	Echo output channels		32	No	0064	Time difference counter			No
0054	Issue processor flag pulse 1	1		Yes	0066	Force Error	1		Yes
0055	Enable input channel timing 1	1		Yes	0067	Interlock Autoload	16870		Yes
0056	Input timing data		2	No	01NN	Autoload from disk			No
0057	Echo one word	1	1	No	03NN	Disk deadstart			No
0061	Autodump		12 288	No	0414	Autoload from PP	16 870		Yes
0062	Manipulate processor	5		No	0720	Echo one word	1	1	No

0001 — SEEK, 1:1 INTERLACE OR 0002 — SEEK, 2:1 INTERLACE

Conditions controller for 1:1 interlace (consecutive sector) or 2:1 interlace (alternate sector) data transfer. When necessary, seek function also reserves drive and initiates or maintains head motion. Zero-filled general status indicates normal completion and on-cylinder drive. PP waiting for seek to complete must reissue seek before requesting general status. Seeks may proceed concurrently on two or more drives, thereby enabling seek overlap.

Once an operation that transfers data with consecutive (1:1 interlace) or alternate (2:1 interlace) sectors becomes on-cylinder, no additional seek functions are required unless the operation continues on another cylinder.

NOTE

A new seek function is always required when changing operations, regardless of starting address (for example, a write followed by a read).

Parameter format:

Word 1	Refer to 0000 - (connect) parameter format
Word 2	Starting cylinder number
Word 3	Starting track number
Word 4	Starting sector number

Address ranges:

Drive	Range		
	Cylinder	Track	Sector
844	0-822	0-18	0-23
885	0-842	0-39	0-31†

0004 — READ

Transfers one sector of data from drive to controller to PP. Previous seek function specifies starting sector. PP must follow each read function with a one-sector block input.

0005 — WRITE

Transfers one sector of data from PP to controller to drive. Previous seek function specifies starting sector. PP must follow each write function with a one-sector block output.

0006 — WRITE VERIFY

Conditions controller to compare PP output data with data from one disk sector. No data transfers to drive. Previous seek function specifies starting sector. PP must follow each write verify function with a one-sector block output.

0007 — READ CHECKWORD

Conditions controller to test one disk sector for checkword errors. No data transfers to PP. Previous seek function specifies starting sector.

0010 — OPERATION COMPLETE

Releases controller and last drive selected by controller, thereby making controller available to other PP accesses. Other drives must previously have been released by 0015 (drop seeks) or 0020 (drive release) function.

NOTE

When issued after an operation complete function, a 0012 (general status) function reserves the controller again.

0011 — DISABLE DRIVE RESERVE

Multiple-controller subsystems only. Releases all 844 drives reserved by another controller. Should be used only when 844 drives are reserved by inoperative controller. Use bit 11 of first parameter sent with 0000 (connect) or 0001/0002 (seek) function to release each 885 drive reserved by inoperative controller.

NOTE

Disable drive reserve function drops 844 drive reserves only if select lines to drives are low. When inoperative controller leaves select lines high, deadstart master clear or controller pushbutton master clear drops reserves.

† Each 885 track has 34 physical sectors and 32 logical sectors. The last two sectors in each track are reserved for use as spares.

0012 — GENERAL STATUS

Transfers general status word from controller to PP. Except as indicated in table 3-1, PP must request and input general status after completing each function. Zero-filled general status indicates normal function completion. Table 3-2 defines general status bits.

TABLE 3-2. GENERAL STATUS

Bit	Definition
11	Abnormal termination. Preceding function terminated abnormally. General status bits 8 and 9 indicate whether recovery is possible. Detailed status shows cause of abnormal termination.
10	Multiple-access controller reserved. Controller is reserved to another PP channel. All other status bits are meaningless.
9	Nonrecoverable error. Controller detected error from which no recovery is possible. Detailed status identifies error.
8	Recovery in process. Controller is ready to attempt error recovery in response to 0014 (continue) function.
7	Checkword error. Controller detected checkword error in address field or data field of sector. Detailed status word 2, bits 8 through 11, provides error analysis.
6	Correctable address error. Controller detected correctable read address checkword error. 0014 (continue) function enables data to be processed on subsequent disk revolution.
5	Unused.
4	Drive malfunction. Drive-related error occurred. Detailed status reflects drive status at time of malfunction.
3	Drive reserved. Requested drive is reserved by other controller.
2	Autoload error. Controlware loaded is not compatible with controller.
1	Busy. Controller and/or requested drive are busy.
0	Unused.

0013 — DETAILED STATUS OR 0023 — EXTENDED DETAILED STATUS

Transfers 12-word (0013) or 20-word (0023) status block from controller to PP. Abnormal termination status (general status bit 11) determines applicability of drive status fields within detailed status block. When abnormal termination is 0, drive status applies to drive referenced by last 0000 (connect) or 0001/0002 (seek) function. When abnormal termination is 1, drive status (if any) is that taken by controller upon abnormal termination of function listed in detailed status word 3.

PP must follow detailed status function with block input of appropriate length. PP may then attempt error recovery with 0014 (continue) function (if general status bit 8 is 1) or may issue new function.

Figure 3-2 shows detailed status block format and table 3-3 defines detailed status bits. Appendix C correlates various subsystem conditions with corresponding general and detailed status.

0014 — CONTINUE

This function is used to step controller through a semiautomatic error recovery sequence, and also to resume formatting after controller has paused following detection of sector or track flaws during 844 pack formatting. Refer to Error Recovery (later in this section) and 0016-format pack function description for additional information concerning use of continue function.

Continue During Error Recovery

PP should issue a continue function and reinitiate previous data transfer when abnormal termination and recovery in progress status (general status bits 11 and 8, respectively) occurs during any of the following function sequences:

0004-Read
0005-Write
0006-Write Verify
0007-Read Checkword
0024-Read Gap Sector
0025-Write Gap Sector
0026-Write Verify Gap Sector
0027-Read Checkword Gap Sector
0030-Read Factory Data
0031-Read Utility Map
0034-Read Protected Sector
0035-Write Last Sector
0037-Write Protected Sector

Continue function enables PP to try up to nine combinations of data strobe and head positioner offset while attempting to read address or data fields. (Controller always writes data at nominal strobe and offset settings.) Since controller tries three times at each combination (one try per continue function) a total of 27 continue functions can be issued before controller declares an error unrecoverable. Strobe and offset combination presently in effect can be determined by checking detailed status word 1, bits 4 through 11. Any seek function or controller-initiated seek operation forces strobe/offset retry count to zero, and each continue function issued during read error recovery increments strobe/retry count by one.

When general status indicates recovery in progress, issuing any function except continue causes controller to exit from error recovery sequence and process new function. PP must read general and detailed status after each continue function to determine state of error recovery efforts. Abnormal termination and nonrecoverable error (general status bits 11 and 9, respectively) indicate controller has aborted error recovery and stopped accepting continue functions.

Controller response to a continue function depends upon type of error encountered (and reported in detailed status) as follows.

- Address field correctable checkword error. Continue function causes controller to read same address field on next disk revolution and begin processing data field if second read was error-free or correctable.

NOTE

In order to ensure that address and data errors that appear to be correctable are in fact correctable (and not caused by intermittent hardware problems rather than media defects), controller corrects apparently correctable checkword errors only after corresponding address or data has been read twice using nominal strobe and offset settings, and second read was error-free or correctable. When a correctable data checkword error occurs during a data field read not using nominal strobe and offset settings, controller declares correctable checkword error (sets bits 9 and 8 of general status to 0 and 1, respectively) and places error location and correction vector in detailed status, but does not correct data returned to PP.

- Address field sync error or noncorrectable checkword error. Each continue function causes controller to reread the address field using strobe and offset settings indicated in detailed status word 1, bits 4 through 11. When a reread attempt results in a correctable checkword error and strobe/offset retry count is less than 4, next continue function causes controller to read and correct address field on next revolution and begin processing data field. If no reread attempt is successful, controller sets nonrecoverable error bit in general status.

- Seek error. First continue function causes controller to determine difference between present cylinder and target cylinder, and to move heads accordingly. If this fails to locate correct cylinder, a second continue function causes controller to reposition heads to cylinder zero and retry seek from there. If neither of these head movements locates proper cylinder, controller sets nonrecoverable error bit in general status.

- Track or sector miscompare. A continue function causes controller to recheck track and sector numbers on next revolution. If miscompare is still present, controller sets nonrecoverable error bit in general status.

- Data field sync error or checkword error. Each continue function causes controller to reread data field using strobe and offset setting indicated in detailed status word 1, bits 4 through 11. When a reread attempt using nominal strobe/offset settings results in a correctable checkword error, next continue function causes controller to correct error before transmitting data to PP.

Continue During 844 Pack Formatting

After completing the formatting requested by a 0016 (format pack) function, the controller sets track and sector flaws in the area just formatted according to the utility flaw map. When the return flaw data bit (parameter word 2, bit 9) is 1, the controller notifies the PP of the sector to be flawed before flawing the sector. To perform this notification, the controller places the address of the sector to be flawed in detailed status and then sets general status to 4400 octal. After reading general and detailed status, the PP issues a continue function to enable the controller to flaw the sector and place the address of the next flawed sector (if there is one) in detailed status.

0015 — DROP SEEKS

Multiple-access drives only. Releases all drives except last drive referenced by 0000 (connect) or 0001/0002 (seek) function. Head motion continues, but each released drive becomes selected to next requesting controller. When reselecting a released drive, PP must issue new seek function to establish initial disk address.

NOTE

0010 (operation complete) and 0020 (drive release) functions can be used to release drives individually.

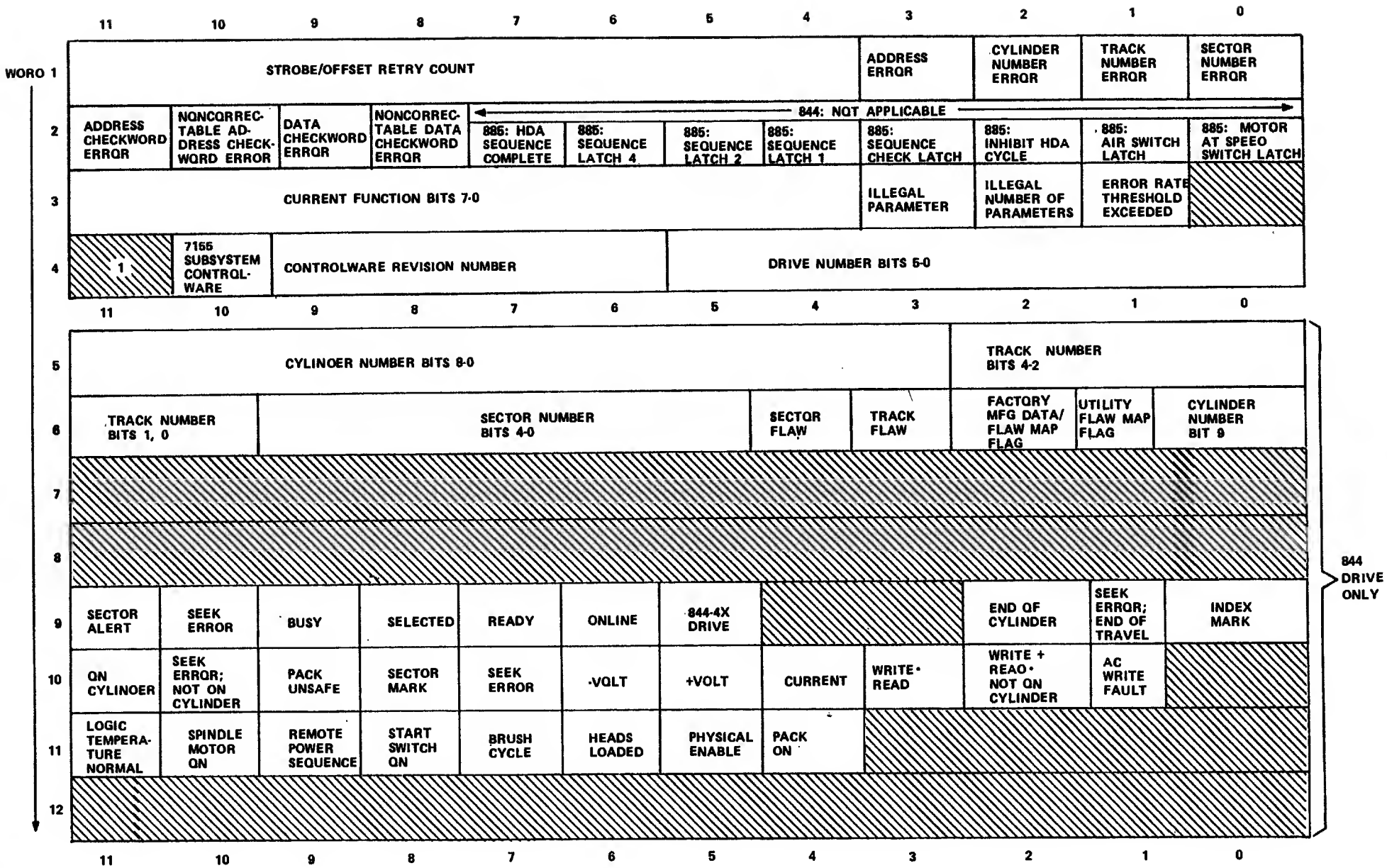


Figure 3-2. Detailed Status (Sheet 1 of 3)

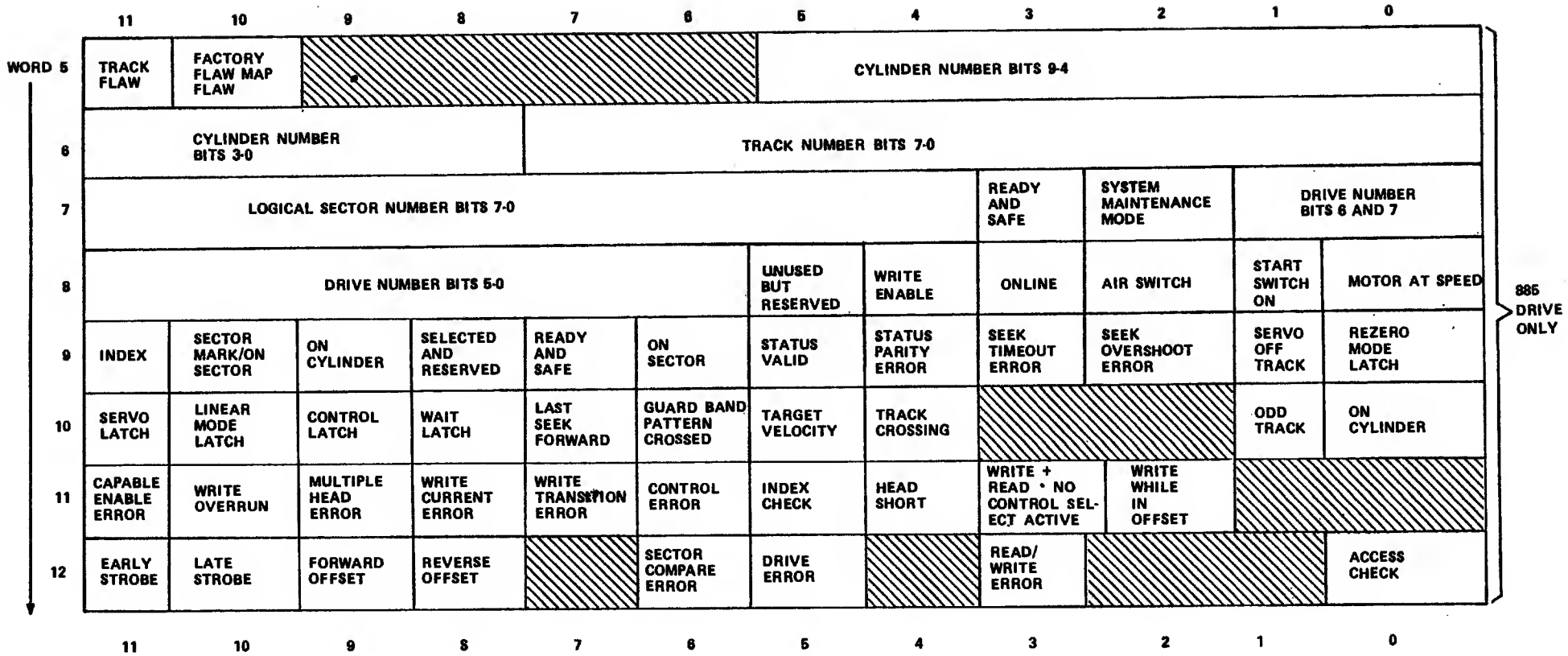


Figure 3-2. Detailed Status (Sheet 2 of 3)

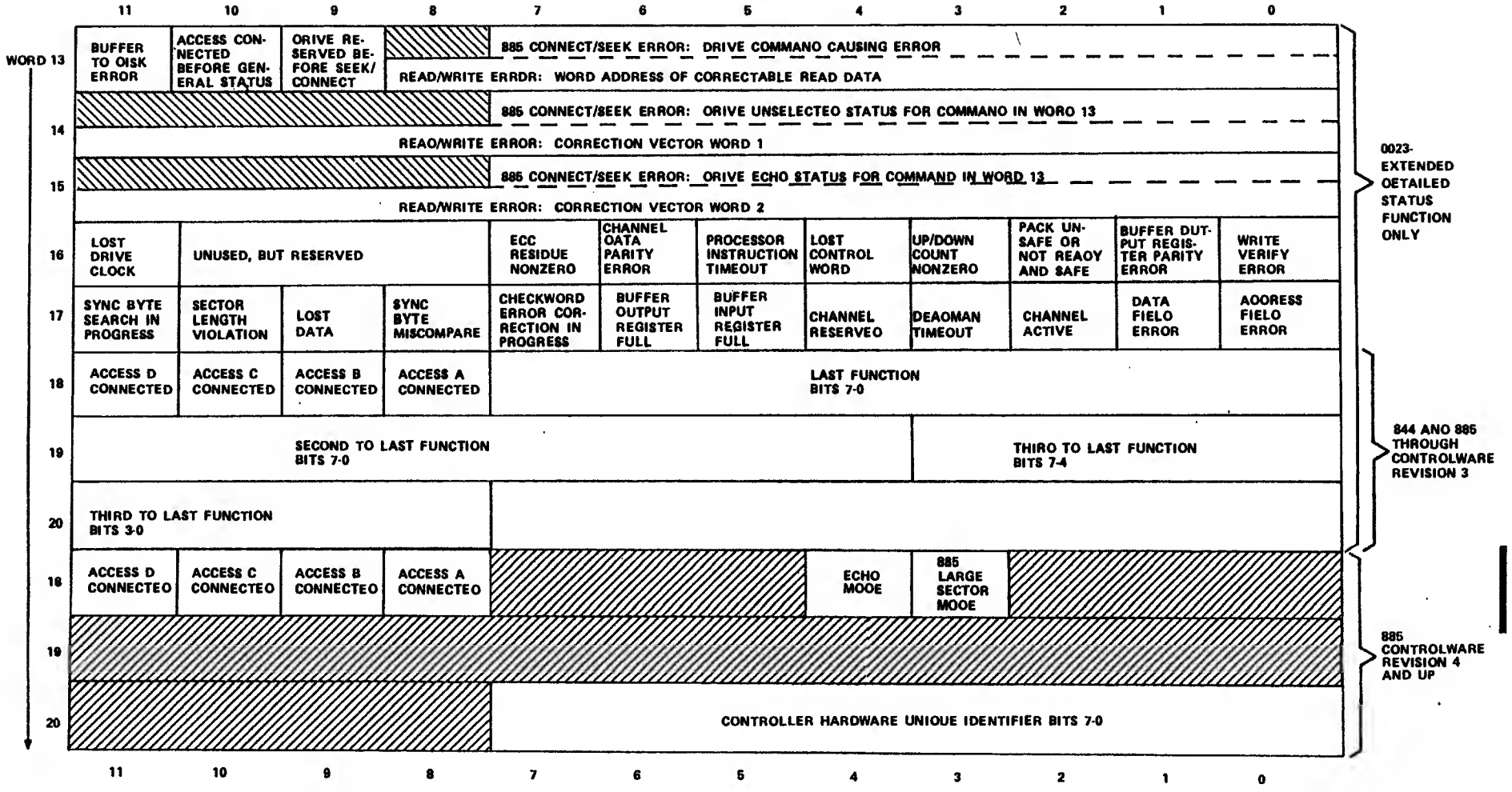


Figure 3-2. Detailed Status (Sheet 3 of 3)

TABLE 3-3. DETAILED STATUS

<table>
<tr><th rowspan="2">Word</th><th rowspan="2">Bit(s)</th><th colspan="2">Applies To</th><th rowspan="2">Definition</th></tr>
<tr><th>844</th><th>885</th></tr>
<tr><td>1</td><td>11-4</td><td>•</td><td>•</td><td>Strobe/offset retry count - Indicates head positioner offset and strobe to be tried next upon receipt of 0014 (continue) function as follows:
<table><tr><td>Count</td><td>1 2 3</td><td>4 5 6</td><td>7 8 9</td><td>10 11 12</td><td>13 14 15</td><td>16 17 18</td><td>19 20 21</td><td>22 23 24</td><td>25 26 27</td></tr><tr><td>Offset</td><td>Nominal</td><td>Nominal</td><td>Nominal</td><td>Reverse</td><td>Reverse</td><td>Reverse</td><td>Forward</td><td>Forward</td><td>Forward</td></tr><tr><td>Strobe</td><td>Nominal</td><td>Early</td><td>Late</td><td>Nominal</td><td>Early</td><td>Late</td><td>Nominal</td><td>Early</td><td>Late</td></tr></table></td></tr>
<tr><td>1</td><td>3</td><td>•</td><td>•</td><td>Address error - PP-specified address does not agree with address from disk.</td></tr>
<tr><td>1</td><td>2</td><td>•</td><td>•</td><td>Cylinder number error - Cylinder number from sector is incorrect.</td></tr>
<tr><td>1</td><td>1</td><td>•</td><td>•</td><td>Track number error - Track number from sector is incorrect.</td></tr>
<tr><td>1</td><td>0</td><td>•</td><td>•</td><td>Sector number error - Sector number from sector is incorrect.</td></tr>
<tr><td>2</td><td>11</td><td>•</td><td>•</td><td>Address checkword error - Checkword error detected after reading address field.</td></tr>
<tr><td>2</td><td>10</td><td>•</td><td>•</td><td>Noncorrectable address checkword error - Address field read cannot be corrected. Address read from disk begins in word 5.</td></tr>
<tr><td>2</td><td>9</td><td>•</td><td>•</td><td>Data checkword error - Checkword error detected after reading data field.</td></tr>
<tr><td>2</td><td>8</td><td>•</td><td>•</td><td>Noncorrectable data checkword error - Data field read contains error that cannot be corrected with 8-bit correction vector. Address of failing sector begins in word 5. (Correctable data checkword error is indicated when general status bits 9 and 8 are 0 and 1, respectively.)</td></tr>
<tr><td>2</td><td>7-0</td><td>•</td><td></td><td>Not applicable.</td></tr>
<tr><td>2</td><td>7</td><td></td><td>•</td><td>Head/disk assembly sequence complete.</td></tr>
<tr><td>2</td><td>6</td><td></td><td>•</td><td>Sequence latch 4.</td></tr>
<tr><td>2</td><td>5</td><td></td><td>•</td><td>Sequence latch 2.</td></tr>
<tr><td>2</td><td>4</td><td></td><td>•</td><td>Sequence latch 1.</td></tr>
<tr><td>2</td><td>3</td><td></td><td>•</td><td>Sequence check latch.</td></tr>
<tr><td>2</td><td>2</td><td></td><td>•</td><td>Inhibit head/disk assembly cycle.</td></tr>
<tr><td>2</td><td>1</td><td></td><td>•</td><td>Air switch latch.</td></tr>
<tr><td>2</td><td>0</td><td></td><td>•</td><td>Motor at speed switch latch.</td></tr>
<tr><td>3</td><td>11-4</td><td>•</td><td>•</td><td>Current function bits 7 through 0 - Lower 8 bits of function causing this copy of detailed status.</td></tr>
<tr><td>3</td><td>3</td><td>•</td><td>•</td><td>Illegal parameter - Illegal parameter(s) received with current function.</td></tr>
<tr><td>3</td><td>2</td><td>•</td><td>•</td><td>Illegal number of parameters - Illegal number of parameters received with current function. (Applies only to functions not causing transfer to disk.)</td></tr>
<tr><td>3</td><td>1</td><td>•</td><td>•</td><td>Error rate threshold exceeded - During last 65 000 read operations on selected drive, controller detected read errors (excluding flaws) after at least three head positioning changes. Threshold counter and read operation counter reset to zero after threshold error or 65 000 read operations.</td></tr>
<tr><td>3</td><td>0</td><td>•</td><td>•</td><td>Unused.</td></tr>
<tr><td>4</td><td>11</td><td>•</td><td>•</td><td>Constant 1.</td></tr>
<tr><td>4</td><td>10</td><td>•</td><td>•</td><td>7155 subsystem controlware - MA721 controlware is resident in controller.</td></tr>
<tr><td>4</td><td>9-6</td><td>•</td><td>•</td><td>Controlware revision number - Revision number of controlware resident in controller.</td></tr>
</table>

TABLE 3-3. DETAILED STATUS (Contd)

Word	Bit(s)	Applies To		Definition
		844	885	
4	5-0	•	•	Drive number - Number of drive associated with this copy of detailed status.
5	11-3	•		Cylinder number bits 8 through 0 - Lower 9 bits of cylinder number.
5	2-0	•		Track number bits 4 through 2 - Upper 3 bits of track number.
6	11,10	•		Track number bits 1 and 0 - Lower 2 bits of track number.
6	9-5	•		Sector number bits 4 through 0.
6	4	•		Sector flaw - This sector has been tagged as bad.
6	3	•		Track flaw - The track containing this sector has been tagged as bad.
6	2	•		Factory manufacturing data/flaw map flag - This sector contains either factory manufacturing data or factory flaw data.
6	1	•		Utility flaw map flag - This sector contains utility flaw data.
6	0	•		Cylinder number bit 9 - Upper bit of cylinder number.
7	11-0	•		Unused.
8	11-0	•		Unused.
9	11	•		Sector alert - Addressed sector is next sector.
9	10	•		Seek error - Seek did not complete in time, heads moved to end of travel, or heads unexpectedly moved from track center.
9	9	•		Busy - Drive is reserved by another controller.
9	8	•		Selected - Drive is selected.
9	7	•		Ready - Pack is spinning and heads are loaded.
9	6	•		Online - Drive is online.
9	5	•		844-4X drive - Double-density 844 drive.
9	4,3	•		Unused.
9	2	•		End of cylinder - Head counter advanced beyond 18.
9	1	•		Seek error; end of travel - Heads moved to end of travel in either direction.
9	0	•		Index mark - Start of track.
10	11	•		On cylinder - Heads are positioned over tracks.
10	10	•		Seek error; not on cylinder - Heads unexpectedly moved from track center.
10	9	•		Pack unsafe - At least one of the error conditions indicated by word 10, bits 6 through 1 exists.
10	8	•		Sector mark - Start of sector.
10	7	•		Seek error - Same indication as word 9, bit 10, seek error.
10	6	•		-Volt - Abnormal negative voltage condition.
10	5	•		+Volt - Abnormal positive voltage condition.

TABLE 3-3. DETAILED STATUS (Contd)

Word	Bit(s)	Applies To		Definition
		844	885	
10	4	•		Current - More than one head selected, both write drivers on, write gate without write data, or selected head open.
10	3	•		Write read - Write gate received while read gate was enabled.
10	2	•		Write + read not on cylinder - Write gate or read gate received while off cylinder.
10	1	•		Alternating current write fault.
10	0	•		Unused.
11	11	•		Logic temperature normal.
11	10	•		Spindle motor on.
11	9	•		Remote power sequence - Drive power is sequenced by controller.
11	8	•		START switch on.
11	7	•		Brush cycle - Pack brush cycle is in progress.
11	6	•		Heads loaded.
11	5	•		Physical enable - Drive cover is closed, DC circuit breakers are closed, and START switch is on.
11	4	•		Pack on - Pack is mounted on spindle.
11	3-0	•		Unused.
12	11-0	•		Unused.
5	11		•	Track flaw - The track containing this sector has been tagged as bad.
5	10		•	Factory flaw map flag - This sector contains factory flaw data.
5	9-6		•	Unused.
5	5-0		•	Cylinder number bits 9 through 4 - Upper 6 bits of cylinder number.
6	11-8		•	Cylinder number bits 3 through 0 - Lower 4 bits of cylinder number.
6	7-0		•	Track number bits 7 through 0.
7	11-4		•	Logical sector number bits 7 through 0.
7	3		•	Ready and safe - Drive is prepared to perform any function.
7	2		•	System maintenance mode - SYST MAINT switch on drive is active.
7	1,0		•	Drive number bits 6 and 7 - Upper 2 bits of drive number. From switches in each drive.
8	11-6		•	Drive number bits 5 through 0 - Lower 6 bits of drive number. From switches in each drive.
8	5		•	Unused, but reserved.
8	4		•	Write enable - Drive is capable of writing (READ ONLY switch is inactive).
8	3		•	Online.

TABLE 3-3. DETAILED STATUS (Contd)

Word	Bit(s)	Applies To 844	Applies To 885	Definition
8	2		•	Air switch - Airflow sensor detects cooling air movement.
8	1		•	Start switch on - START switch on drive operator panel is active.
8	0		•	Motor at speed - Pack is rotating at nominal speed.
9	11		•	Index - Start of track.
9	10		•	Sector mark/on sector - Start of record or on sector condition.
9	9		•	On cylinder - Drive is following track.
9	8		•	Selected and reserved - Drive is selected and available.
9	7		•	Ready and safe - Drive is prepared to perform any function.
9	6		•	On sector.
9	5		•	Status valid - Controller may sample drive status.
9	4		•	Status parity error - Controller detected drive status parity error.
9	3		•	Seek timeout error - Seek did not complete within 180 milliseconds.
9	2		•	Seek overshoot error - Carriage moved too rapidly, did not stop at proper cylinder, or moved into crash stop.
9	1		•	Servo off track - Track following failure before or during read/write operation.
9	0		•	Rezero mode latch } These bits indicate state of drive access control as follows:
10	11		•	Servo latch
10	10		•	Linear mode latch
10	9		•	Control latch
10	8		•	Wait latch

Word, Bit					Hexadecimal Decode	Access Control State
9,0	10,11	10,10	10,9	10,8		
0	0	0	0	1	01	Wait
0	0	0	0	0	00	Start rezero
1	0	0	0	0	10	Move out
1	0	0	1	0	12	Turn around
1	0	1	1	0	16	Move in
0	0	1	1	0	06	Rezero linear mode
0	1	1	1	0	0E	On track
0	1	0	1	0	0A	Accelerate
0	1	0	0	0	08	Decelerate
0	1	1	0	0	0C	Seek linear mode

TABLE 3-3. DETAILED STATUS (Contd)

Word	Bit(s)	Applies To		Definition
		844	885	
10	7		•	Last seek forward.
10	6		•	Guard band pattern crossed - Carriage crossed one or both outer band patterns.
10	5		•	Target velocity - Actual head velocity equals desired head velocity.
10	4		•	Track crossing - Servo track crossing pulse.
10	3,2		•	Unused.
10	1		•	Odd track.
10	0		•	On cylinder.
11	11		•	Capable enable error - Writing attempted with READ ONLY operator panel switch active or reading/writing attempted with drive not ready or servo not in track following mode.
11	10		•	Write overrun - Writing attempted through index mark.
11	9		•	Multiple head error - More than one head per arm selected.
11	8		•	Write current error - Drive detected no write current during write operation or drive detected write current while reading.
11	7		•	Write transition error - Drive detected no write transitions within 4 microseconds of write gate or drive detected write transitions in absence of write gate or while reading.
11	6		•	Control error - Write gate present with unsquelch or read gate.
11	5		•	Index check - Drive failed to decode index mark from servo disk.
11	4		•	Head short - More than one head selected.
11	3		•	Write + read • no control select active.
11	2		•	Write while in offset.
11	1,0		•	Unused.
12	11		•	Early strobe.
12	10		•	Late strobe.
12	9		•	Forward offset.
12	8		•	Reverse offset.
12	7		•	Unused.
12	6		•	Sector compare error - Drive detected two index marks without detecting on-sector condition.
12	5		•	Drive error - At least one of the conditions indicated by word 2, bit 3; or word 9, bits 3, 2, 1; or word 12, bit 6 exists.
12	4		•	Unused.
12	3		•	Read/write error - Drive detected at least one of the error conditions indicated by word 11.
12	2,1		•	Unused.
12	0		•	Access check - Drive detected positioner failure.

TABLE 3-3. DETAILED STATUS (Contd)

Word	Bit(s)	Applies To 844	Applies To 885	Definition
13	11	•	•	Buffer to disk error - Controller detected error while transferring data from buffer to disk during 1:1 interlace write or 2:1 interlace 885 write.
13	10	•	•	Access connected before general status - Enables each of two or more PPs using same channel (and therefore, same controller access) to determine whether access was already connected when PP issued general status function. To ensure validity of this bit, all PPs using same channel must begin each operation with a 0012 (general status) function followed by a 0023 (extended detailed status) function.
13	9	•	•	Drive reserved before seek/connect - Enables each of two or more PPs using same controller and drive to determine whether drive was already reserved to controller when PP issued 0000 (connect) or 0001/0002 (seek) function.
				NOTE Word 13, bits 8 through 0 and words 14 and 15 apply only to 885 drive connect/seek errors or correctable read/write errors.
13	8		•	885 connect/seek error - Unused.
13	7-0		•	885 connect/seek error: Drive command causing error - Command decode sent to drive that resulted in error. Possible decodes are:

Hexadecimal Decode	Command
40	Load upper cylinder register
41	Load lower cylinder register
42	Load upper difference counter
43	Load lower difference counter
48	Start seek
4A	Clear fault
80	Read upper cylinder register
81	Read lower cylinder register

13	8-0	•	•	Read/write error: Word address of correctable read data - Location in data field of 12-bit word modified by correction vector word 1. First location is 000. For error logging only.
14	11-8		•	885 connect/seek error - Unused.
14	7-0		•	885 connect/seek error: Unselected status for command in word 13 - Definitions for word 14, bits 7 through 0 are identical to those for word 9, bits 11 through 4. Word 14 status is that returned for command in word 13.
14	11-0	•	•	Read/write error; Correction vector word 1 - First word of 24-bit correction vector that controller applied to data field with logical difference operation. For error logging only.
15	11-8		•	885 connect/seek error - Unused.

TABLE 3-3. DETAILED STATUS (Contd)

Word	Bit(s)	Applies To 844	Applies To 885	Definition
15	7-0		•	885 connect/seek error: Drive echo status for command in word 13 - Echo status returned by drive for command in word 13. Status descriptions for each possible command decode are:

Hexadecimal Command Decode	Echo Status Bits 7	6	5	4	3	2	1	0
40	Upper cylinder register							
41	Lower cylinder register							
42	Forward	Upper difference counter						
43	Lower difference counter							
48	Control select	Access error	Drive check	Read/ write check	Online			Offset active
4A	Control select	Access error	Drive check	Read/ write check	Online			On track
80	Upper cylinder register							
81	Lower cylinder register							

15	11-0	•	•	Read/write error: Correction vector word 2 - Second word of 24-bit correction vector that controller applied to data field with logical difference operation. For error logging only.
16	11	•	•	Lost drive clock - Drive read/write clock absent for at least 340 nanoseconds.
16	10-8		•	Unused, but reserved.
16	7	•	•	Error correction code (ECC) residue nonzero.
16	6	•	•	Channel parity error - Controller detected parity error on data transfer from PP to the connected access. Operation completes despite parity error.
16	5	•	•	Processor instruction timeout - 30-millisecond timeout occurred while processor awaited read next instruction (RNI) occurrence during data transfer on a processor channel. Subsequent processor channel transfers (except one-word inputs) fall through until instruction timeout condition clears.
16	4	•	•	Lost control word - During control word sequence, bit counter became zero before controller detected next control word.
16	3	•	•	Up/down count nonzero - Number of buffer words read was less than number of buffer words written during normal read/write operation.
16	2	•	•	Pack unsafe or not ready and safe - Drive detected failure and is not safe for reading/writing.
16	1	•	•	Buffer output register parity error - Controller detected parity error during buffer operation. Operation completes despite parity error.
16	0	•	•	Write verify error - Controller detected miscompare during write verify operation. Operation completes despite error.
17	11	•	•	Sync byte search in progress.
17	10	•	•	Sector length violation - Sector mark occurred while read gate or write gate was active. Operation in progress halts with error.
17	9	•	•	Lost data - Buffer failed to exchange data with shift register fast enough to match disk transfer rate. Operation in progress halts with error.

TABLE 3-3. DETAILED STATUS (Contd)

Word	Bit(s)	Applies To 844	Applies To 885	Definition
17	8	•	•	Sync byte miscompare - Sync byte read from drive did not compare with sync byte supplied by controller.
17	7	•	•	Checkword error correction in progress - Controller is determining whether checkword error is correctable.
17	6	•	•	Buffer output register full.
17	5	•	•	Buffer input register full.
17	4	•	•	Channel reserved - Data path between connected access and buffer is enabled. Controller disables this path between functions to prevent PP to PP transfers on disk channel from interacting with controller.
17	3	•	•	Deadman timeout - Connected access has not transferred word on active PP channel for 4.8 ± 0.5 seconds. Controller has deactivated channel.
17	2	•	•	Channel active - PP channel selected by processor channel 0, bits 0 and 1 is active.
17	1	•	•	Data field error.
17	0	•	•	Address field error.
18	1	•	•	Access D connected.
18	0	•	•	Access C connected.
18	9	•	•	Access B connected.
18	8	•	•	Access A connected.
18	7-0	•	•	Last function bits 7 through 0 - Lower 8 bits of last function processed.
				NOTE Controller does not record 0013/0023 (detailed status) functions in words 18 through 20. Descriptions for these words are valid only through controlware revision 03. Status descriptions for revision 04 and up are listed below.
19	11-4	•	•	Second to last function bits 7 through 0 - Lower 8 bits of second to last function processed.
19	3-0	•	•	Third to last function bits 7 through 4 - Upper 4 bits of lower 8 bits of third to last function processed.
20	11-8	•	•	Third to last function bits 3 through 0 - Lower 4 bits of third to last function processed.
20	7-0	•	•	Fourth to last function bits 7 through 0 - Lower 8 bits of fourth to last function processed.

The following applies to controlware revisions 04 and higher only.

18	11-8	•	•	Same as above.
18	7-5	•	•	Unused.
18	4		•	Echo mode. Drive status from 885 is invalid.
18	3		•	Large Sector Mode.
18	2-0	•	•	Unused.
19	11-0	•	•	Unused.
20	11-8	•	•	Unused.
20	7-0	•	•	Controller hardware unique identifier bits 7-0. From switches on controller card A07.

0016 — FORMAT PACK

Writes new address and data fields on a disk pack or HDA using nominal head positioner offset and strobe settings. Table 3-4 shows the 844 and 885 sector format patterns. A new pack must be entirely formatted before the PP directs read/write functions to it. Each format pack function requires a seven-word parameter block, whose content varies with the type of format operation as described in the following paragraphs.

CAUTION

All format operations destroy data residing in the area being formatted. Before attempting to reformat a disk area containing customer data or flaw maps, ensure that the data has been archived to another device.

TABLE 3-4. SECTOR FORMAT PATTERNS

Order	Field	Number of Bits 844	885
1	Sync pattern 1	312	200
2	Sync byte 1	6	8
3	Address field	24	32
4	Address checkword	32	48
5	Sync pattern 2	102	152
6	Sync byte 2	6	8
7	Data field	3864	3864
8	Data checkword	32	48
9	Pad byte	6	8
10	Tolerance gap	96	304
	Total	4480	4672

The 844 recording frequency is 6.45 million bits per second. The 885 recording frequency is 9.58 million bits per second.

Formatting 844 Pack

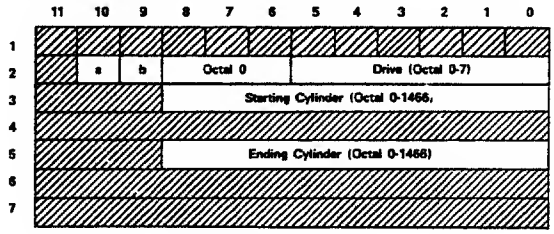
Upon receipt of a format pack function and the parameter block shown in figure 3-3, the controller first ensures that a utility map is present on the pack. If the map is not present, the controller returns 5000 general status and aborts the function. Otherwise, the controller formats the entire pack or selected cylinders according to the parameter block. The controller does not format factory and utility map areas (cylinder 822; track 0; sectors 0, 1, 2). Formatting the entire 844 pack requires a minimum of 5 minutes.

When formatting is complete and the return flaw data bit (parameter word 2, bit 9) is 0, the controller places sector and track flaw bits (as required) in the address headers of all sectors that have flaw entries in the utility map. Factory flaw criteria for the disk packs used on 844-4x drives are:

Sector flaw — The sector contains a defect that prevents the controller from reading it without a correctable or noncorrectable error.

Track flaw — The track contains more than 12 sector flaws.

When the return flaw data bit is 1 and the controller has completed the formatting specified in the format pack parameter block, the controller reads from the utility flaw map the first sector flaw address corresponding to the area just flawed, places this address in detailed status, and sets general status to 4400 octal. Upon detection of the 4400 general status, the PP may take detailed status to obtain the flaw address and then issue a 0014 (continue) function. This causes the controller to set the appropriate flaw bits in the address field of the sector just identified in detailed status, to transfer the address of the next flawed sector from the utility flaw map to detailed status, and to set general status to 4400. When the PP has received the last sector flaw address corresponding to the area just formatted, the controller sets general status to 0000.



a Format entire pack
b Return flaw data

Figure 3-3. 844: Format Multiple Track Parameters

Formatting 844 Map Sectors

Figure 3-4 shows the format pack parameter block used for reformatting an 844 factory or utility map sector. Refer to appendix D for map addresses and data formats.

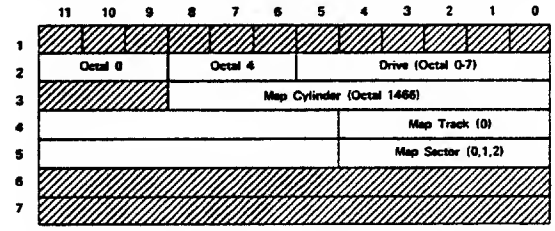
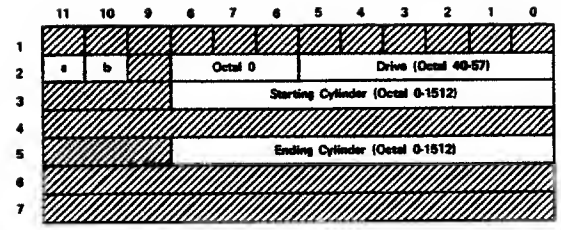


Figure 3-4. 844: Format Map Sector Parameters

Formatting 885 HDA

Upon receipt of a format pack function and the parameter block shown in figure 3-5, the controller formats all 34 physical sectors on each track of the entire 885 HDA or the selected cylinders. The controller does not format the tracks containing factory and utility flaw maps (cylinder 841, tracks 0, 1). When the save controlware track bit (parameter word 2, bit 11) is 1, the controller does not format the track containing 7155 controlware (cylinder 841, track 2). During formatting, the controller neither checks for flaws nor modifies the contents of flaw maps. Formatting an entire HDA requires a minimum of 10 minutes.



a Save controlware track
b Format entire HDA

Figure 3-5. 885: Format Multiple Track Parameters

After the entire HDA is formatted, the PP must use a read factory data (0030) function to read the defective sectors table in the utility map (cylinder 841, track 1, sectors 2-18), and then must reformat any track containing one or more defective sectors.

The defective sectors table in the factory map contains the address of each sector unable to record information without error. The defective sectors table in the utility map starts out as a copy of the defective sectors table in the factory map, and also may contain user entries.

For each 885 track with one or two entries in the defective sectors table of the utility map, the PP should issue one format pack function with the parameter block shown in figure 3-6. This zero-fills defective sector(s) and readjusts logical sector numbers to allow use of the spare sector(s) at the end of the track.

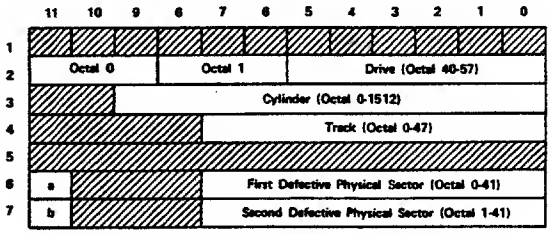
For each 885 track with more than two entries in the defective sectors table of the utility map, the PP should issue 34 format pack functions (one function for each physical sector on the track) using the parameter block shown in figure 3-7 for good sectors, and using the parameter block shown in figure 3-8 for defective sectors. This sets the track flaw bit in each good sector on the track and zero-fills each defective sector.

NOTES

The PP should ignore defective sector entries for flaw map tracks (cylinder 841, tracks 0, 1).

Formatting is not required to switch between 885 small and large sector modes. Reference 885-1X large sector section, this manual.

After any 885 format operation (and required zero-filling of defective sectors and flawing of tracks) the PP should verify that the defective sectors table and the track flaw table in the utility map accurately reflect the condition of the HDA. After verifying the tables, the PP can determine unusable areas of the HDA by consulting the track flaw table alone. The PP need reference the defective sectors table only when reformatting tracks containing defective sectors.



a When 1, indicates no defective sectors
b When 1, indicates no second defective sector

Figure 3-6. 885: Format Track (Zero, One, or Two Skipped Sectors) Parameters

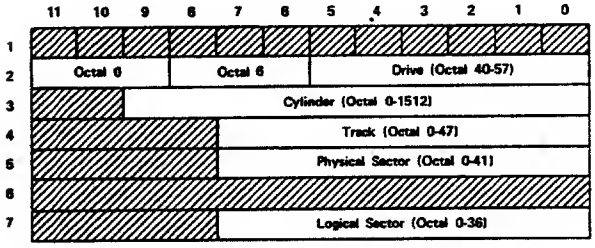


Figure 3-7. 885: Format Good Sector (More Than Two Skipped Sectors in Track) Parameters

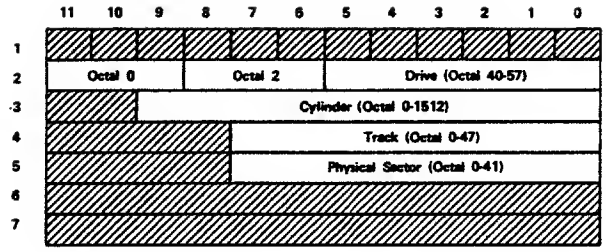


Figure 3-8. 885: Format Defective Sector (More Than Two Skipped Sectors in Track) Parameters

Formatting 885 Utility Map

Use format pack function and parameter block shown in figure 3-9 to format an 885 utility map sector. The controller does not allow formatting of 885 factory map sectors.

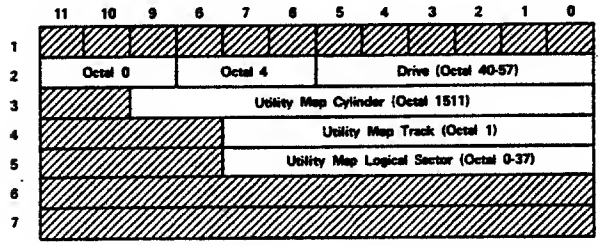


Figure 3-9. 885: Format Utility Map Sector Parameters

0017 — RETURN DRIVE ADDRESS

Transfers three-word general status/drive address block from controller to PP. Word 1 is general status applicable to last connect (0000) or seek (0001/0002) function. Word 2 contains current (0000 general status) or destination (0002 general status) cylinder address. When general status is 0000, word 3 contains physical sector number of sector currently under read/write heads. Table 3-5 lists physical sector number ranges and approximate sector times for 844 and 885 drives. For 885 drives, the controller identifies the 93-microsecond tolerance gap between physical sector 33 and physical sector 0 as sector 34.

TABLE 3-5. PHYSICAL SECTOR TIMES

Drive	Physical Sector	Time per Sector
844	0–23	695 microseconds
885	0–33	487 microseconds
885	34	93 microseconds

0020 — DRIVE RELEASE

Releases reserve on last drive accessed by controller. Does not clear controller access connection.

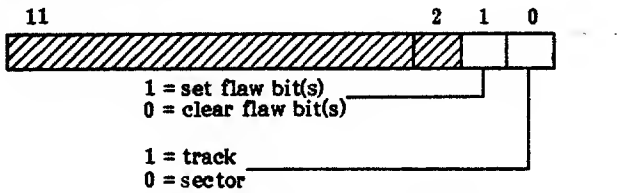
0021 — RETURN CYLINDER ADDRESS

Transfers from drive to controller to PP one word containing current (zero-filled general status) or destination (0002 general status) cylinder address. PP must have previously reserved drive with 0000 (connect) function.

0022 — SET/CLEAR FLAW

844 drives only. Sets/clears flaw bit(s) on individual track or sector, then automatically seeks to and updates utility map. Controller returns 0002 general status word while drive seeks to utility map. PP must have previously issued successful 0001/0002 (seek) function that specified track/sector requiring flaw bit change(s).

Parameter format:



PP should use following procedure when flaw bit changes are required for 885 drive.

1. Use 0030 (read factory data) function(s) to read defective sectors map.
2. Use 0016 (format pack) function(s) to set track flaw bits or to zero-fill defective sectors and reformat good sectors as necessary.
3. Use 0037 (write protected sector) function(s) to update utility map as necessary.

0023 — EXTENDED DETAILED STATUS

Refer to 0013 (detailed status) function description.

0024 — READ GAP SECTOR,
0025 — WRITE GAP SECTOR,
0026 — WRITE VERIFY GAP SECTOR, AND
0027 — READ CHECKWORD GAP SECTOR

These functions are identical to corresponding 0004 through 0007 functions except for number of skipped sectors between logical sectors. Gap sector completes the function it replaces, then skips an additional two sectors. Refer to table 3-6.

TABLE 3-6. SKIPPED SECTORS BETWEEN LOGICAL SECTORS

Interlace	Number of Skipped Sectors Between Logical Sectors	
	Nongap Sector Functions	Gap Sector Functions
1:1	0	2
2:1	1	3

0030 — READ FACTORY DATA

Identical to 0004 (read) function except read data must come from any pack data area described in appendix D except 844 utility map.

0031 — READ UTILITY MAP

844 drives only. Identical to 0004 (read) function except read data must come from 844 utility map described in appendix D.

0032 — BLOCK TRANSFER BUFFER READ

Transfers 322 12-bit words from controller buffer to PP. As in 0004 (read) function, each word transferred is rightmost 12 bits of 16-bit buffer word. PP must follow block transfer buffer read function with 322-word block input.

0033 — BLOCK TRANSFER BUFFER WRITE

Transfers 322 12-bit words from PP to controller buffer. As in 0005 (write) function, each word transferred is rightmost 12 bits of 16-bit buffer word. PP must follow block transfer buffer write function with 322-word block output. In case of channel parity error or if controller receives less than 322 words, controller returns 5000 general status.

0034 — READ PROTECTED SECTOR

Identical to 0004 (read) function except read data must come from sector written with 0037 (write protected sector) function.

0035 — WRITE LAST SECTOR

Identical to 0005 (write) function except when 1:1 interlace is selected, controller returns general status after rather than before transferring data from buffer to disk. Since this prevents next physical sector from being written without an additional disk revolution, PP should issue write last sector function only for last sector of block.

0036 — WRITE VERIFY LAST SECTOR

Identical to 0006 (write verify) function except when 1:1 interlace is selected, controller returns general status after rather than before verifying sector. Since this prevents next physical sector from being verified without an additional disk revolution, PP should issue write verify last sector function only for last sector of block.

0037 — WRITE PROTECTED SECTOR

Identical to 0035 (write last sector) function except seek preceding write protected sector function must specify one of following sectors.

844 drive	Cylinder 822, track 0, sector 0, 1, or 2 or sector having sector flaw bit set in address field.
885 drive	Cylinder 841, track 1, sectors 0 through 31 or sector having track flaw bit set in address field.

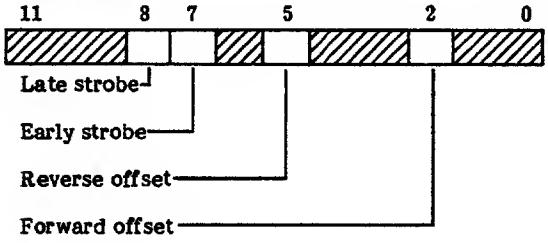
0040 — READ SHORT

Diagnostic use only. Identical to 0004 (read) function except controller transfers 319 words (844) or 318 words (885) to PP and disables checkword error logic before processing controller-generated checkword. This allows PP to test controller checkword error logic by reading sector that contains fixed checkword as last portion of data field. PP must follow read short function with 319-word (844) or 318-word (885) block input. Table 3-7 shows possible write test patterns for use with read short function.

0041 — SELECT STROBE AND OFFSET

Disk pack margin testing only. Selects abnormal strobe/head positioner offset for subsequent read-type functions. Next 0000 (connect) or 0001/0002 (seek) function returns strobe/offset to nominal. Controller does not reply to any function during 10 milliseconds required for offset change to or from nominal. Write-type functions are illegal when strobe/offset are not nominal. Figure 3-10 shows strobe/offset read sequence.

Parameter format:



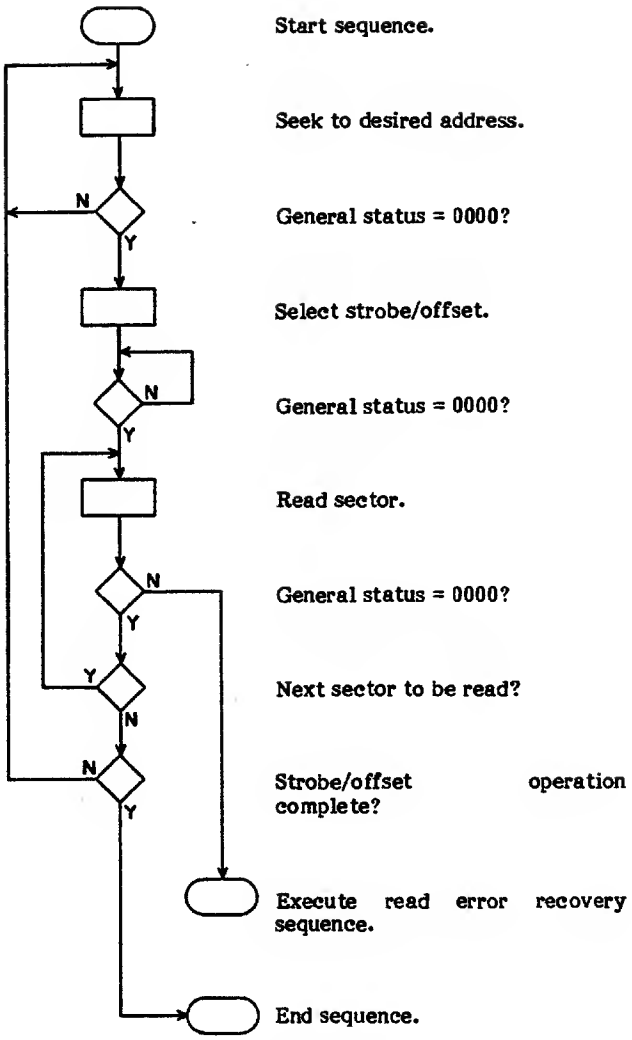


Figure 3-10. Strobe/Offset Read Sequence

TABLE 3-7. WRITE TEST PATTERNS FOR USE WITH READ SHORT FUNCTION

Test	Write Test Pattern					General Status Expected After Read Short Function
	Word 1	Word 2	Words 3-318	Words 319-322		
				844	885	
No checkword error	0000	0000	0000	0000	7777	0000
Correctable checkword error	4000	0000	0000	0000	7777	4600†
Noncorrectable checkword error	4000	4000	0000	0000	7777	4600††

†Detailed status word 2, bit 8 should be 0.
††Detailed status word 2, bit 8 should be 1. General status becomes 5200 after 27 retries.

0042 — CLEAR CONNECTED ACCESS

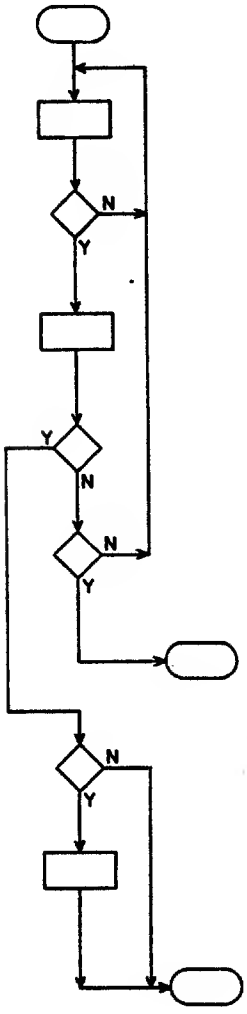
Hung controller condition only. Clears connected access, thereby enabling controller to connect to next access receiving function.

0043 — BUFFER READ AND 0044 — BUFFER WRITE

Identical to 0032/0033 (block transfer buffer read/write) functions except controller uses alternate logic to control transfers.

0046 — WRITE BUFFER TO DISK

Transfers one sector of data from controller buffer to drive. Previous seek function specifies starting sector. Write buffer to disk function provides alternate recovery method for buffer to disk (detailed status word 13, bit 11) write errors. Figure 3-11 shows recommended buffer to disk error recovery sequence.



Start sequence.

Issue seek function.

General status = 0000?

Issue 0046 (write buffer to disk) function.

General status = 0000?

0046 function tried three times?

Abort sequence.

Is next physical sector to be written a gap sector?

Issue seek function for next sector.

Resume normal write/general status function sequence.

Figure 3-11. Buffer to Disk Error Recovery Sequence

0047 — SCAN CYLINDER ADDRESSES

885 drives only. Causes controller to read all address fields on one cylinder and to generate buffer table entries for abnormal sectors. PP must precede scan cylinder addresses function with 0001 (seek, 1:1 interlace) function that specifies cylinder to be scanned. PP should use 0032 (block transfer buffer read) function or 0043 (buffer read) function to input scan results. General status is 0002 while controller performs scan.

Buffer table contains up to 160 two-word entries. Table entry format is as follows:

Word	11 — 6	5 — 0
1	Table entry code	
2	Track number (0-39)	Physical sector number (0-33)

Table entry codes are:

Word 1 Code	Description
0000	Indicates end of table.
0001	Word 2 contains physical address of defective sector.
0002	Word 2 contains address of flawed track (one address per flawed track).
0003	Word 2 contains physical address of: • Sector that is first logical sector on flawed track, but whose logical sector number is not 0. • Sector on flaw map track having flaw map bit not set. • Sector on flawed track having track flaw bit not set. • Sector having incorrect address. • Sector having address checkword error.

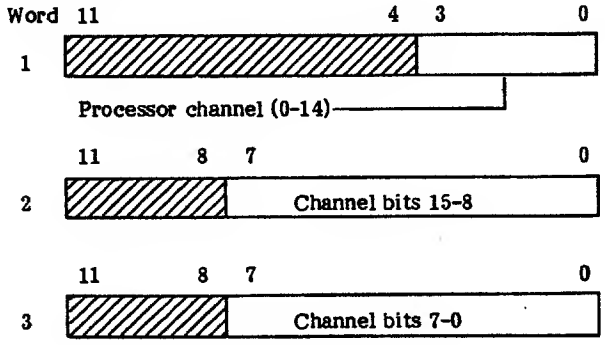
0050 — OUTPUT ON PROCESSOR CHANNEL

CAUTION

Incorrect use of this function can destroy disk pack data.

Diagnostic use only. Outputs 16-bit value on processor channel within controller. Refer to controller hardware maintenance manual listed in preface for processor channel bit descriptions.

Parameter format:



0051 — EXECUTE CONTROL WORD SEQUENCE

CAUTION

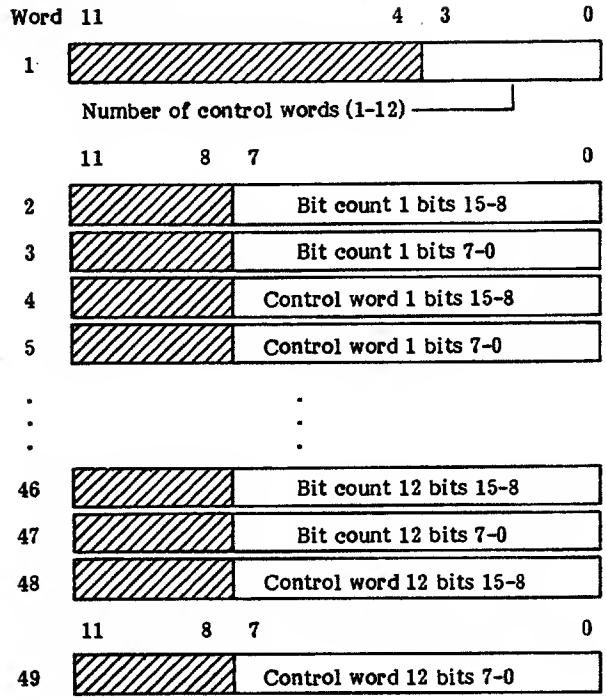
Incorrect use of this function can destroy disk pack data.

Diagnostic use only. Transfers up to 12 16-bit bit count words and associated control words from PP to controller, then initiates control word execution. Controller outputs bit count words on processor channel 4 and outputs control words on processor channel 5. Each bit count word must be large enough to allow its associated control word to execute for at least 3 microseconds. Controller issues terminate control word flag pulse before last control word to prevent lost control word status (extended detailed status word 16, bit 4).

NOTE

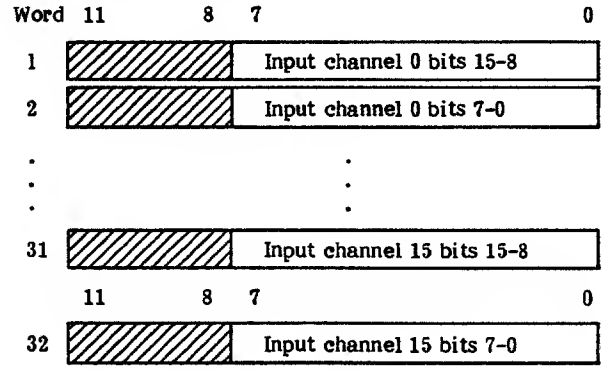
PP must send all 49 parameter words regardless of number of control words to be executed.

Parameter format:



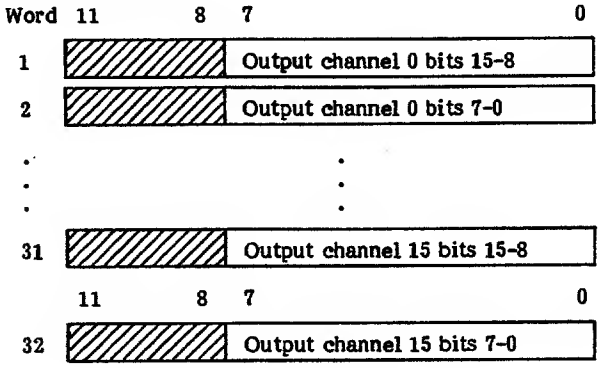
0052 — INPUT PROCESSOR CHANNEL STATUS

Diagnostic use only. Transfers contents of processor input channels 0 through 15 from controller to PP. If it does not input all 32 words, PP must deactivate channel. Controller to PP transfer format is as follows:



0053 — ECHO OUTPUT CHANNELS

Diagnostic use only. Transfers contents of processor output channels 0 through 15 from controller to PP. Before issuing echo output channels function, PP should issue series of 0050 (output on processor channel) functions to place echo values on all processor channels. If it does not input all 32 words, PP must deactivate channel. Controller to PP transfer format is as follows:



0054 — ISSUE PROCESSOR FLAG PULSE

Diagnostic use only. Outputs flag pulse on processor channel within controller. Parameter word contains code that specifies processor channel number. Refer to controller hardware maintenance manual listed in preface for flag pulse descriptions.

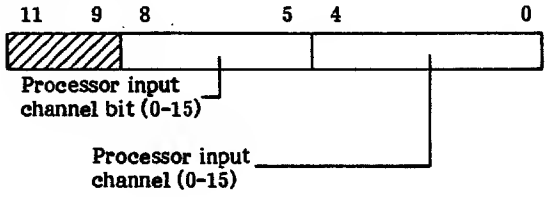
Parameter format:

Flag Code	Processor Channel	Flag Pulse
0	0	Clear connected accesses
1	1	Master clear control logic
2	2	Start error correction
3	3	Clear ECC register
4	4	Clear internal status
5	5	Terminate control word
6	6	Clear access control logic
7	7	Set reserve latch
11	11	Load ECC register

0055 — ENABLE INPUT CHANNEL TIMING

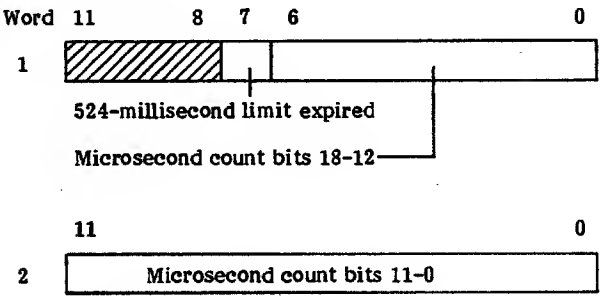
Diagnostic use only. Specifies processor input channel bit to be timed by controller after next 0050 (output on processor channel) or 0051 (execute control word sequence) function. Timer runs until specified processor input channel bit becomes 1 or until 524-millisecond limit occurs. Controller does not reply to functions during timing operation. 0056 (input timing data) function transfers timing data from controller to PP.

Parameter format:



0056 — INPUT TIMING DATA

Diagnostic use only. Transfers from controller to PP timing data collected in response to last 0055/0050/0051 function sequence or 0064 function. Controller to PP transfer format is as follows:



0057 — ECHO ONE WORD OR 0720 — ECHO ONE WORD

Diagnostic use only. Causes controller to accept one word (regardless of channel parity error status) and return it to PP. When word to be echoed has parity error, controller returns ones complement of word to PP. Figure 3-12 shows echo sequence.

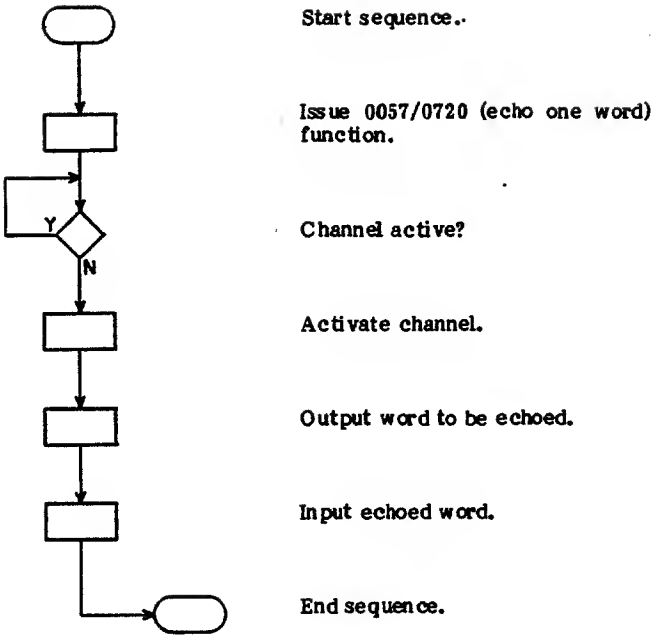
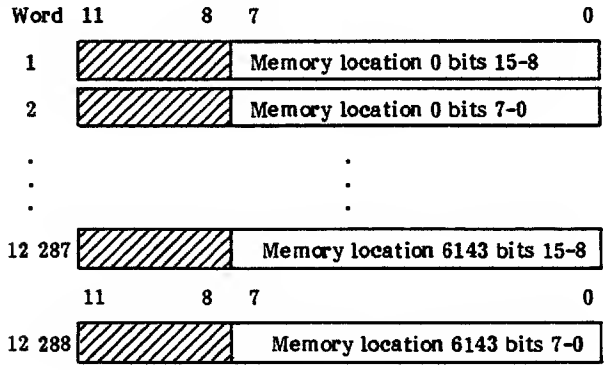


Figure 3-12. Echo Sequence

0061 — AUTODUMP

Diagnostic use only. Transfers entire contents of processor memory from controller to PP. If it does not input all 12 288 words, PP must deactivate channel. Controller to PP transfer format is as follows (all numbers are decimal):

If a deadstart dump is being done, the deadstart master clear will force controller ROM diagnostics and alter some controlware locations. To avoid this, disable the channel access switches while deadstarting, then enable them before the autodump function is sent.



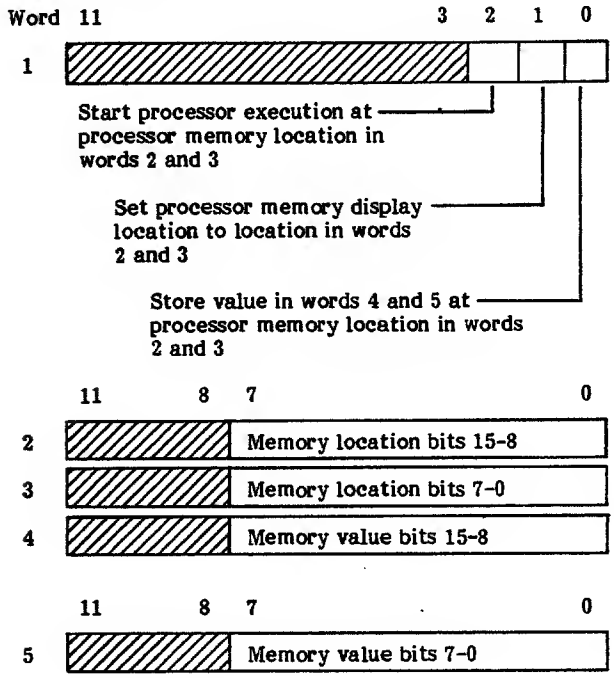
0062 — MANIPULATE PROCESSOR

Diagnostic use only. Allows PP to:

- Store value in RAM or buffer portion of processor memory.
- Set processor memory display location for subsequent 0063 (input display data) function(s).
- Start processor execution at any location in processor memory.

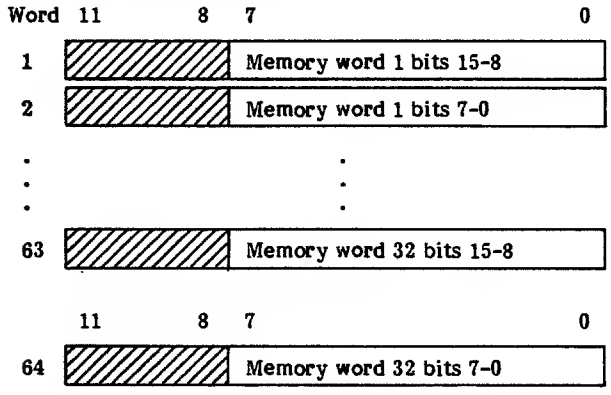
Each processor instruction sequence must end with long jump to address contained in processor memory location 104_8. Refer to controller hardware maintenance manual listed in preface for processor instruction descriptions.

Parameter format:



0063 — INPUT DISPLAY DATA

Diagnostic use only. Transfers 32 16-bit processor memory words from controller to PP starting at location set by preceding 0062 (manipulate processor) function. If it does not input all 64 12-bit words, PP must deactivate channel. Controller to PP transfer format is as follows:



0064 — TIME DIFFERENCE COUNTER

885 drive diagnostic use only. Causes controller to issue 256-cylinder forward seek to drive and time difference counter as it goes from 10 to 8, and to prepare timing data for transfer to PP via 0056 (input timing data) function. PP should position drive to cylinder 0 before issuing time difference counter function.

0066 — FORCE ERROR (not available in model A controllers)

This command allows the PP to cause one of four RAM parity errors or a recoverable write buffer to disk error on the next data function issued.

One word parameter format:

0000-Non buffer to disk RAM P.E., WBDF non zero†

0001-Non buffer to disk RAM P.E., WBDF zero†

0002-Write buffer to disk RAM P.E., WBDF zero†

0003-Read function incomplete transfer RAM P.E.

0004-Non P.E. write buffer to disk error, WBDF zero†

0067 — INTERLOCK AUTOLOAD

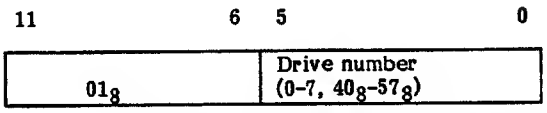
This command will do a full download of controlware but will not force ROM. The drives will not be released.

01NN — AUTOLOAD FROM DISK

NOTE

Execution of this function as described requires RAM controlware and a processor/memory/controller diagnostic to be resident on selected drive.

Causes controller to execute autoload sequence shown in figure 3-13. Function word format is as follows:



Diagnostic and RAM controlware are located on 30 consecutive sectors in 1:1 interlace format at following addresses:

885: cylinder 841, track 2, sectors 1 through 30

844: cylinder 822, track 1, sectors 0 through 23, and cylinder 822, track 2, sectors 0 through 5

This data is packed, with each sector containing 241 16-bit words followed by 8 bits of zero fill.

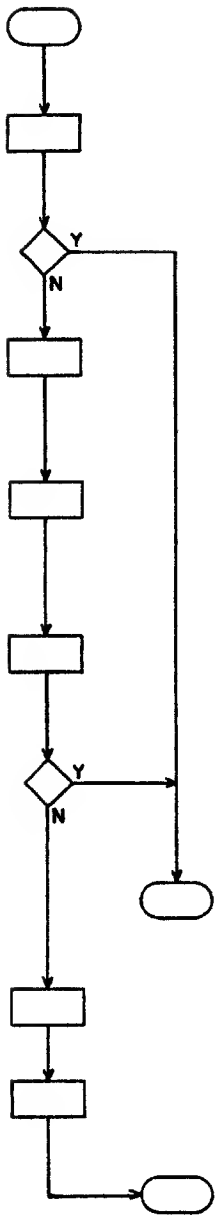
03NN — DISK DEADSTART

Connects access, positions selected drive to deadstart sector, and transfers up to 322 words from drive to controller to PP. When transfer completes, controller releases drive, clears access connection, and prepares general/detailed status identical to that prepared after 0001/0002 (seek) and 0004 (read) functions.

Deadstart sector is cylinder 822, track 0, sector 3 for 844 drives and cylinder 841, track 1, sector 30 for 885 drives. First word in deadstart sector must specify number of words to be transferred. Use 0037 (write protected sector) function to place bootstrap program in deadstart sector.

Address field of 844 deadstart sector must have sector flaw bit set. When it is not flawed from factory, use 0022 (set/clear flaw) function to flaw deadstart sector. To prevent pack interchange problems, check head alignment before flawing deadstart sector.

†WBDF is location 321 of program memory and may be examined via the 62 and 63 functions. A zero in WBDF indicates a buffer to disk error (reference detailed status word 13 bit 11). This cell should be used rather than detailed status because the latter cannot be guaranteed under RAM parity conditions.



Receive 01NN (autoload from disk) function.

Execute processor ROM instruction test.

ROM instruction test error?

Position drive to cylinder 822 (844 drive) or 841 (885 drive).

Transfer processor/memory/ controller diagnostic to controller. Execute diagnostic and save error status.

Transfer RAM controlware to controller. Calculate checksum and compare it with correct value.

Diagnostic error, checksum error, or incorrect controlware loaded?

Halt; corrective maintenance required.

Reply to function.

Release drive.

Enter function idle loop.

Figure 3-13. Controller Activity During Autoload from Disk Function

†Must be 7540 if CC is 00.

Address field of 885 deadstart sector has factory flaw map flag set. This flag is set when pack leaves factory.

Example deadstart panel setting is as follows:

Octal Setting	Description
75CC†	Deactivate channel CC.
77CC 03NN	Issue disk deadstart function specifying drive NN.
74CC	Activate channel CC.
71CC ADDR	Input deadstart data on channel CC to PP location ADDR.

CC must be 00, 12_8, or 13_8 for 12-channel computer.

CC must be 00, 12_8, 13_8, 32_8, or 33_8 for 24-channel computer.

0414 — AUTOLOAD FROM PP

Transfers 16870 12-bit words of autoload data from PP to processor memory within controller. PP to controller transfer format is as follows (all numbers are decimal).

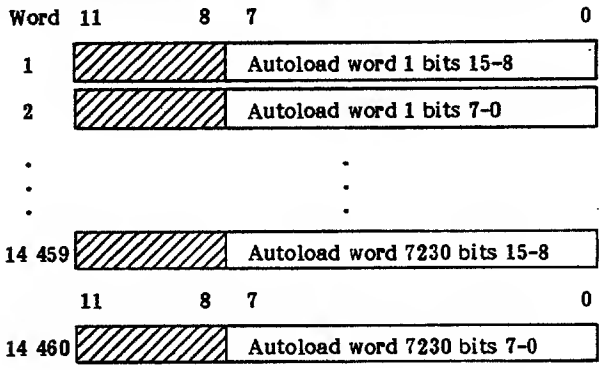


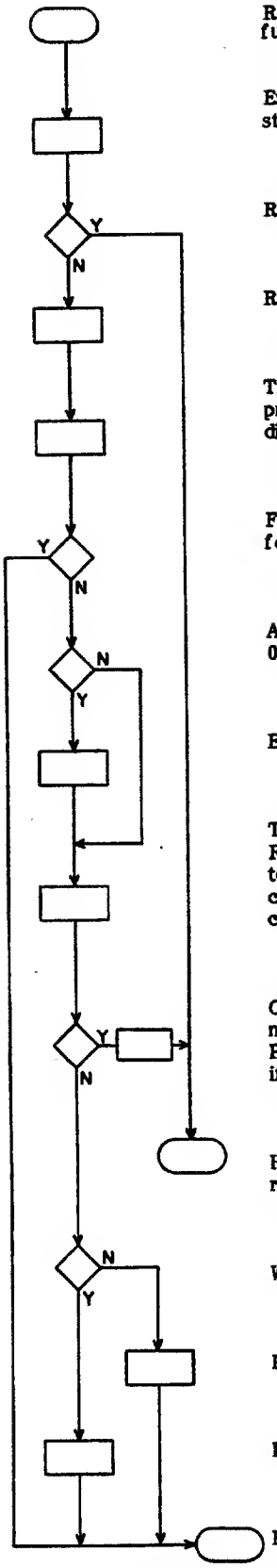
Figure 3-14 shows controller activity during 0414 (autoload from PP) function.

0720 — ECHO ONE WORD

Refer to 0057 (echo one word) function description.

ERROR RECOVERY

A PP uses general status to determine whether subsystem operations are proceeding normally. Zero-filled general status indicates the preceding function completed without error. 4XXX general status indicates the controller has detected a potentially recoverable error, has switched to



Receive 0414 (autoload from PP) function.

Execute processor ROM instruction test.

ROM instruction test error?

Reply to function.

Transfer the 4820 12 bit word processor/memory/controller diagnostic from PP to controller.

Four or fewer words transferred?

Are first two words of transfer 0140, 0000?

Execute diagnostic.

Transfer the 12 050-12 bit word RAM controlware block from PP to controller. Calculate checksum and compare it with correct value.

Channel parity error, diagnostic error, or checksum error? Prepare 5XXX (xxx=error code) if diagnostic error.

Halt; corrective maintenance required.

Was the 7155 controlware loaded?

Prepare 5004 general status.

Prepare 0000 general status.

Enter function idle loop.

Figure 3-14. Controller Activity During Autoload from PP Function

recovery mode, and is ready to accept a 0014 (continue) function in place of the failing function. 5XXX general status indicates the preceding function resulted in a nonrecoverable error. Refer to appendix B for status associated with specific error conditions.

When 4XXX general status indicates a potentially recoverable error, the PP should do the following until general status becomes 00XX or 5XXX.

- Request detailed status for error logging.
- Issue 0014 (continue) function in place of failing function.
- Reinitiate appropriate data transfer.

When 5XXX general status indicates a nonrecoverable error, the PP should:

- Reissue failing function a number of times.
- Check after each try for 00XX or 4XXX general status.
- Request detailed status for error logging as required.
- Abort function sequence if 5XXX general status persists.

Figure 3-15 is a suggested error recovery sequence for failing functions receiving function replies. Figure 3-16 is a suggested error recovery sequence for 1:1 interlace write-type functions not receiving function replies. Table 3-8 shows potentially recoverable read/write errors and the number of times the 0014 (continue) function (and appropriate data transfer) may have to be issued for recovery.

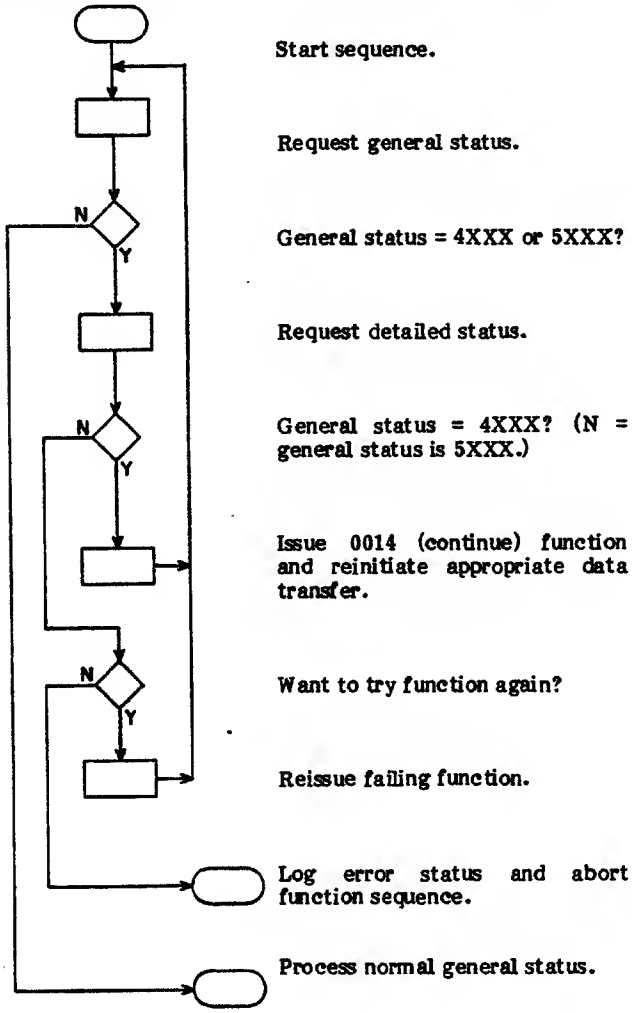


Figure 3-15. Generalized Error Recovery Sequence

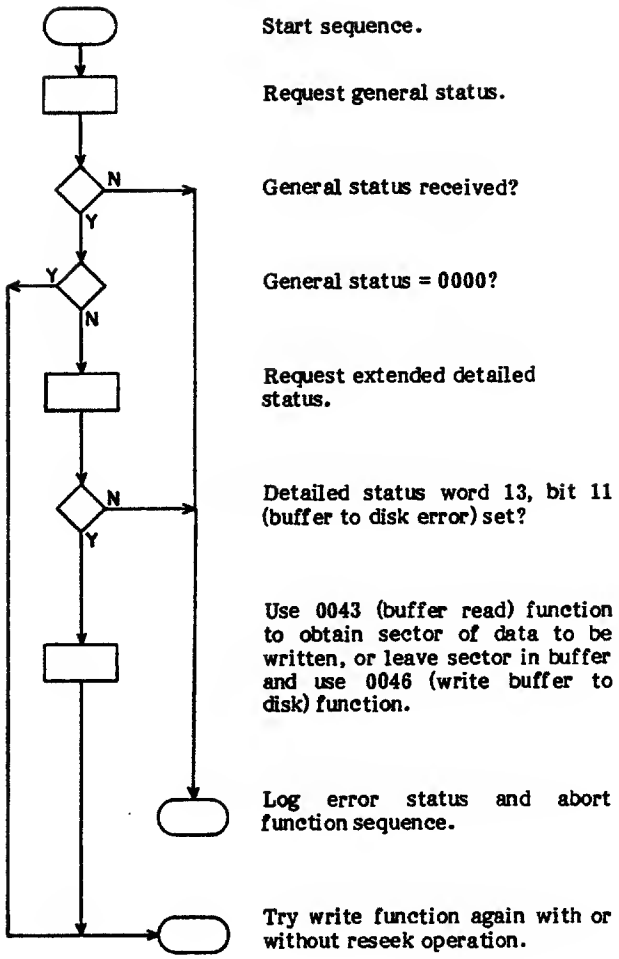


Figure 3-16. 1:1 Interlace Write Error Recovery Sequence

TABLE 3-8. POTENTIALLY RECOVERABLE READ/WRITE ERRORS

Function Type	Error	Number of 0014 (Continue) Functions Required
All	Address sync	1 to 27 (number required = A)
	Address checkword	1 to 27-A
	Head positioning	1 or 2
	Track/sector compare	1
Read	Data sync	1 to 27 (number required = D)
	Data checkword	1 to 27-D
Write	Channel parity	1 to 3

885-1X LARGE SECTOR OPERATION

A 1 to 1 seek command with parameter word 1 bit 9 set selects the large sector. Physically it consists of four sectors. The sector number sent in parameter word 4 of the seek command must contain the physical starting address of the large sector (0, 4, 8, 12, 16, 20, 24, 28). Each of the 4 physical sectors comprising the large sector contains an address field. The subsystem controlware will read each of the 4 address and data fields, skipping defective sectors if present, and combine the data to form one large sector.

Since no address fields are destroyed, reformating the pack is not necessary if switching pack usage from large to small sectors. The address returned in detailed status word 7 will contain the small logical sector number (0 to 31).

GLOSSARY

Access	The logical interface between a PP channel and the controller. A controller can have from one to four accesses.
Address Field	The portion of each sector that identifies the sector's location on the disk pack. An address field contains cylinder/-track/sector numbers and bit(s) to flag the sector or its track as flawed.
Buffer	A portion of processor memory used for temporary data storage during data transfer operations.
Channel	A PP channel from a CDC 6000 series, CDC CYBER 70 model 72/73/74, or CDC CYBER 170 series computer.
Checkword	A code used for detecting/correcting errors in the preceding address or data field.
Controller	A 7155 Disk Storage Controller.
Controlware	Controller-resident code that determines the functional characteristics of the controller. MA721 is the equipment configurator for controlware used in the 7155 controller.
Cylinder	All of the tracks at one head position.
Data Field	The portion of each sector that contains 322 12-bit words of data.
Deadman Timer	A controller circuit that deactivates the connected channel when the channel is active, but has failed to transfer a word for approximately 5 seconds.
Deadstart	The process of changing the state of a computer system from not running to running. The operating system is assumed not to be resident in central memory at deadstart time.
Disk	Refer to disk pack.
Disk Pack	An assembly of magnetically coated disks used for data storage. The disk pack used with 844 drives is removeable, while the disk pack used with 885 drives is fixed.
Drive	An 844-4x Double Density Disk Storage Unit or one spindle of an 885 Disk Storage Unit.
Drive Channel	The logical interface between a controller and a drive. An 844 drive has two or four drive channels and an 885 drive has one drive channel with a second channel optional.
End-of-Record Byte	A byte that appears after the data checkword to indicate the end of a sector.
Fixed Module Drive	Another name for the 885 drive. Abbreviated FMD.
Flaw	A defect in the magnetic coating of a disk pack that prevents error-free data storage. Sectors or tracks containing flaws are not used for data storage.
Function	A 12-bit code issued by a PP to the controller to initiate subsystem activity. Section 3 describes functions applicable to the 7155 subsystem.
Gap Sector	A sector that is skipped during a data transfer operation to allow additional time for PP overhead.
Head	A device that translates electric current to magnetic flux changes on a rotating disk pack and vice versa.
Head/Disk Assembly	An assembly containing the heads, disk pack, and protective shroud for an 885 drive. Abbreviated HDA.
Head Positioner	The servo-controlled voice coil actuator used to position heads in a drive.

Interlace	The ratio of number of sectors processed to number of sectors actually passing the head.
Operation	A subsystem task controlled by one or more PP-issued functions.
Overhead	Program activity not directly related to transferring data to or from the disk.
Pack	Refer to disk pack.
Parameter	One or more 12-bit words issued by a PP after a function to provide the controller with information relative to the function.
Processor	A microprocessor within the controller programmed to execute a modified CDC CYBER PP instruction set.
Processor Channels	Controller internal paths used by the processor to monitor/control subsystem activities and to communicate with the PP.
Processor Memory	A memory used by the processor for controlware storage and for temporary data storage.
Random Access Memory	A portion of processor memory used for controlware storage. Abbreviated RAM.
Read Only Memory	A nonvolatile, read-only portion of processor memory containing brief processor tests and code for processing controller autoload-related functions. Abbreviated ROM.
Sector	An arc of contiguous magnetic flux changes traced on a disk pack by a head.
Subsystem	A collection of disk storage equipment that may include one or more controllers, one to eight 844 drives per controller, and two to sixteen 885 drives per controller.
Sync Pattern	A series of flux changes that synchronizes drive read electronics with the first bit of an address or data field.
Tolerance Gap	A field placed at the end of each sector to ensure that drive motor speed variations do not result in writing into the next sector.
Track	The circle of flux changes traced on a disk pack by a head at one head position.

Table B-1 lists function reply times, data/parameter window times, and total execution times for each function.

Function reply time is the time between function issue by PP and function reply (channel deactivation) by controller. Unless otherwise indicated, function reply times assume that the preceding function has completed, that the controller is waiting for another function, and that the controller is connected to the access receiving the function.

The minimum data/parameter window time is the shortest amount of time between function reply and data/parameter transfer. When the PP has not started data/parameter transfer by the maximum window time, the controller prepares error status and waits for the next function.

Total execution time begins when the controller detects the function and ends when the controller starts waiting for the next function. The maximum execution time is usually the result of an error condition. For example, the 300-millisecond maximum execution time for the 0004 (read) function is determined by the worst case return to zero seek time.

Figures B-1 through B-7 show timing for operations that transfer disk data.

Use table B-1 to determine timing for individual functions; use figures B-1 through B-7 to determine timing for complete operations.

TABLE B-1. FUNCTION TIMING DATA

Octal Code	Function	Time (Minimum/Maximum)			Notes
		Function Reply	Data/Parameter Window	Total Execution	
0000	Connect	20 µs/30 µs	5 µs/4.8 s	60 µs/4.8 s	
0001	Seek, 1:1 interlace	20 µs/30 µs	5 µs/4.8 s	60 µs/4.8 s	
0002	Seek, 2:1 interlace	20 µs/30 µs	5 µs/4.8 s	60 µs/4.8 s	
0004	Read	20 µs/30 µs	8 µs/1 rev	620 µs/300 ms	†
0005	Write	25 µs/75 µs	5 µs/1 rev	620 µs/300 ms	†
0006	Write verify	25 µs/75 µs	5 µs/1 rev	620 µs/300 ms	†
0007	Read checkword	30 µs/40 µs	Not applicable	620 µs/300 ms	†
0010	Operation complete	30 µs/40 µs	Not applicable	35 µs/45 µs	
0011	Disable drive reserve	40 µs/45 µs	Not applicable	45 µs/50 µs	
0012	General status	15 µs/20 µs	5 µs/4.8 s	35 µs/4.8 s	††
0013	Detailed status	20 µs/30 µs	15 µs/4.8 s	60 µs/4.8 s	
0014	Continue	Not applicable	Not applicable	Not applicable	†††
0015	Drop seeks	130 µs/140 µs	Not applicable	135 µs/145 µs	
0016	Format pack	20 µs/30 µs	5 µs/4.8 s	300 µs/600 s	††††
0017	Return drive address	15 µs/20 µs	5 µs/4.8 s	35 µs/4.8 s	
0020	Drive release	30 µs/40 µs	Not applicable	35 µs/45 s	
0021	Return cylinder address	20 µs/30 µs	5 µs/4.8 s	30 µs/4.8 s	
0022	Set/clear flaw	20 µs/30 µs	5 µs/4.8 s	50 ms/4.8 s	
0023	Extended detailed status	20 µs/30 µs	15 µs/4.8 s	100 µs/4.8 s	
0024	Read gap sector	20 µs/30 µs	8 µs/1 rev	620 µs/300 ms	
0025	Write gap sector	25 µs/75 µs	5 µs/1 rev	620 µs/300 ms	
0026	Write verify gap sector	25 µs/75 µs	5 µs/1 rev	620 µs/300 ms	
0027	Read checkword gap sector	30 µs/40 µs	Not applicable	620 µs/300 ms	

NOTE

Time abbreviations are: µs (microsecond), ms (millisecond), rev (revolution), s (second).

†Not maintaining interlace. Refer to figures B-1 through B-7.
††General status function reply time is 20 µs/50 ms when controller is connected to another access.
†††Refer to times for function in progress.
††††Formatting entire pack.

TABLE B-1. FUNCTION TIMING DATA (Contd)

Octal Code	Function	Time (Minimum/Maximum)			Notes
		Function Reply	Data/Parameter Window	Total Execution	
0030	Read factory data	20 μs/30 μs	8 μs/1 rev	620 μs/300 ms	†
0031	Read utility map	20 μs/30 μs	8 μs/1 rev	620 μs/300 ms	†
0032	Block transfer buffer read	20 μs/30 μs	5 μs/4.8 s	200 μs/4.8 s	
0033	Block transfer buffer write	20 μs/30 μs	5 μs/4.8 s	200 μs/4.8 s	
0034	Read protected sector	20 μs/30 μs	8 μs/1 rev	620 μs/300 ms	†
0035	Write last sector	25 μs/75 μs	5 μs/1 rev	620 μs/300 ms	†
0036	Write verify last sector	25 μs/75 μs	5 μs/1 rev	620 μs/300 ms	†
0037	Write protected sector	25 μs/75 μs	5 μs/1 rev	620 μs/300 ms	†
0040	Read short	20 μs/30 μs	8 μs/1 rev	620 μs/300 ms	†
0041	Select strobe and offset	20 μs/30 μs	5 μs/4.8 s	75 s/4.8 s	
0042	Clear connected access	20 μs/50 ms	Not applicable	20 s/50 ms	
0043	Buffer read	20 μs/30 μs	5 μs/2 ms	200 μs/2 ms	
0044	Buffer write	20 μs/30 μs	5 μs/2 ms	200 μs/2 ms	
0046	Write buffer to disk	25 μs/75 μs	Not applicable	620 μs/300 ms	†
0047	Scan cylinder address	20 μs/30 μs	Not applicable	650 ms/705 ms	
0050	Output on processor channel	20 μs/30 μs	5 μs/4.8 s	60 μs/4.8 s	
0051	Execute control word sequence	20 μs/30 μs	5 μs/4.8 s	190 μs/4.8 s	
0052	Input processor channel status	20 μs/30 μs	5 μs/4.8 s	120 μs/4.8 s	
0053	Echo output channels	20 μs/30 μs	5 μs/4.8 s	120 μs/4.8 s	
0054	Issue processor flag pulse	20 μs/30 μs	5 μs/4.8 s	60 μs/4.8 s	
0055	Enable input channel timing	20 μs/30 μs	5 μs/4.8 s	35 μs/4.8 s	
0056	Input timing data	20 μs/30 μs	5 μs/4.8 s	40 μs/4.8 s	
0057	Echo one word	20 μs/30 μs	5 μs/4.8 s	40 μs/4.8 s	
0061	Autodump	20 μs/30 μs	5 μs/4.8 s	7 ms/4.8 s	
0062	Manipulate processor	20 μs/30 μs	5 μs/4.8 s	80 μs/4.8 s	
0063	Input display data	20 μs/30 μs	5 μs/4.8 s	100 μs/4.8 s	
0064	Time difference counter	20 μs/30 μs	Not applicable	22 ms/25 ms	
0066	Force Error	20 μs/30 μs	5 μs/4.8 s	32 μs/4.8 s	
0067	Interlock Autoload	85 μs/95 μs	5 μs/4.8 s	155 μs/4.8 s	
01NN	Autoload from disk	650 μs/1.1 s	Not applicable	Not applicable	
03NN	Disk deadstart	100 μs/50 ms	100 μs/1 rev	700 μs/300 ms	
0414	Autoload from PP	30 ms/35 ms	5 μs/4.8 s	185 ms/4.8 s	
0720	Echo one word	20 μs/30 μs	5 μs/4.8 s	40 μs/4.8 s	

† Not maintaining interlace. Refer to figures B-1 through B-7.

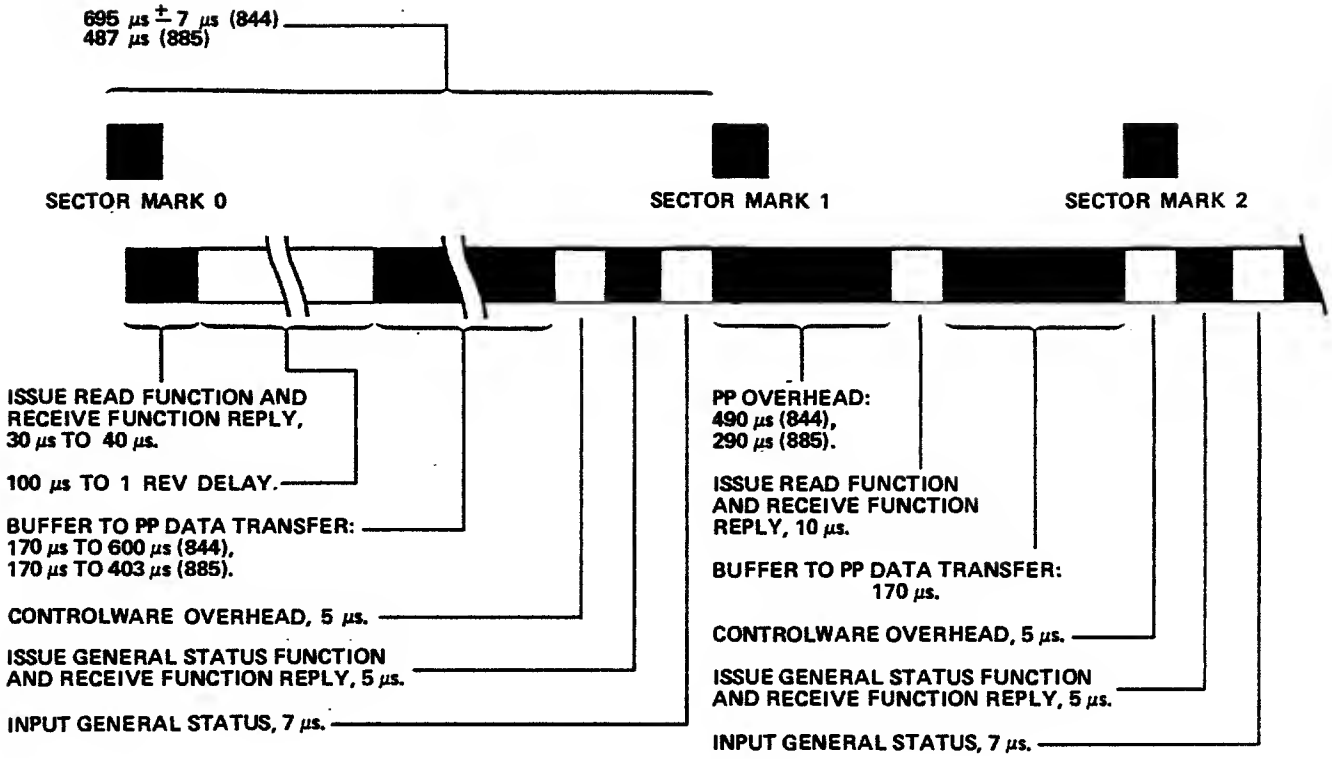


Figure B-1. 1:1 Interlace Read (2-MHz PP)

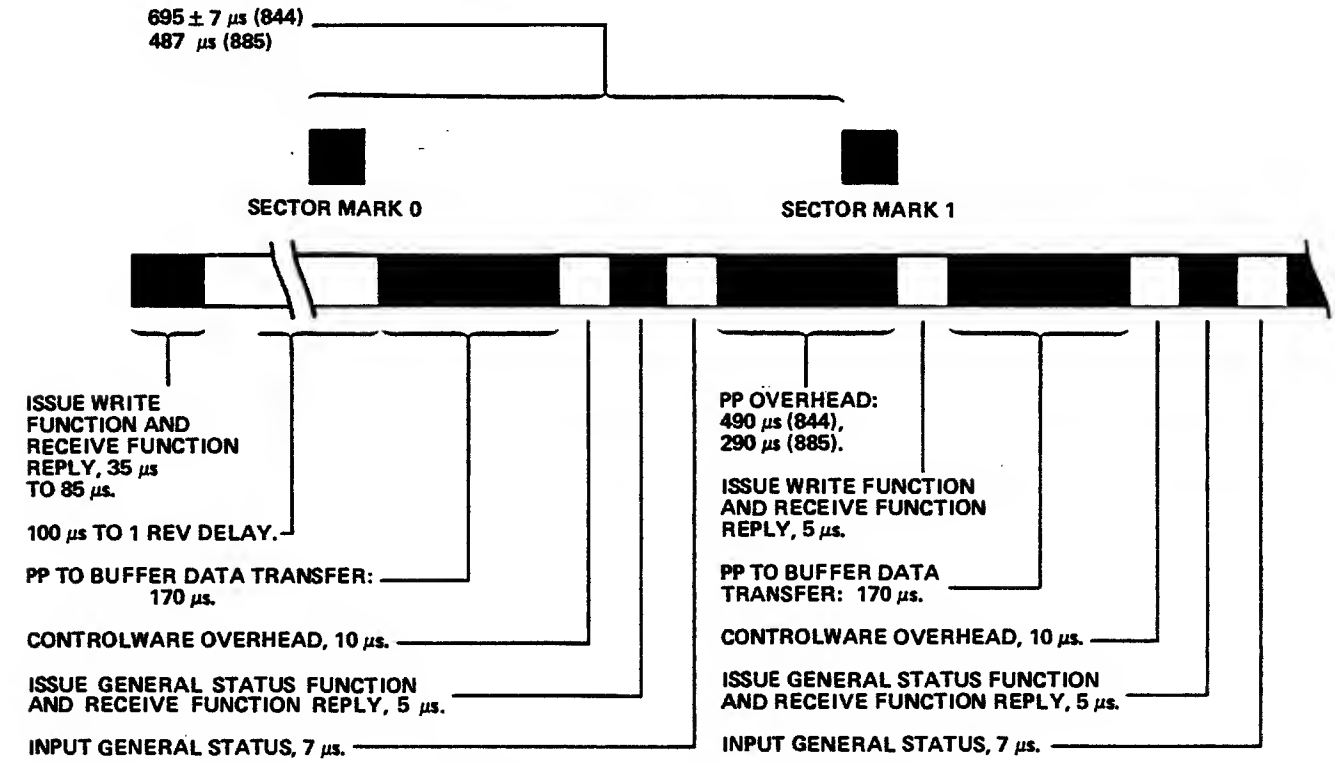


Figure B-2. 1:1 Interlace Write (2-MHz PP)

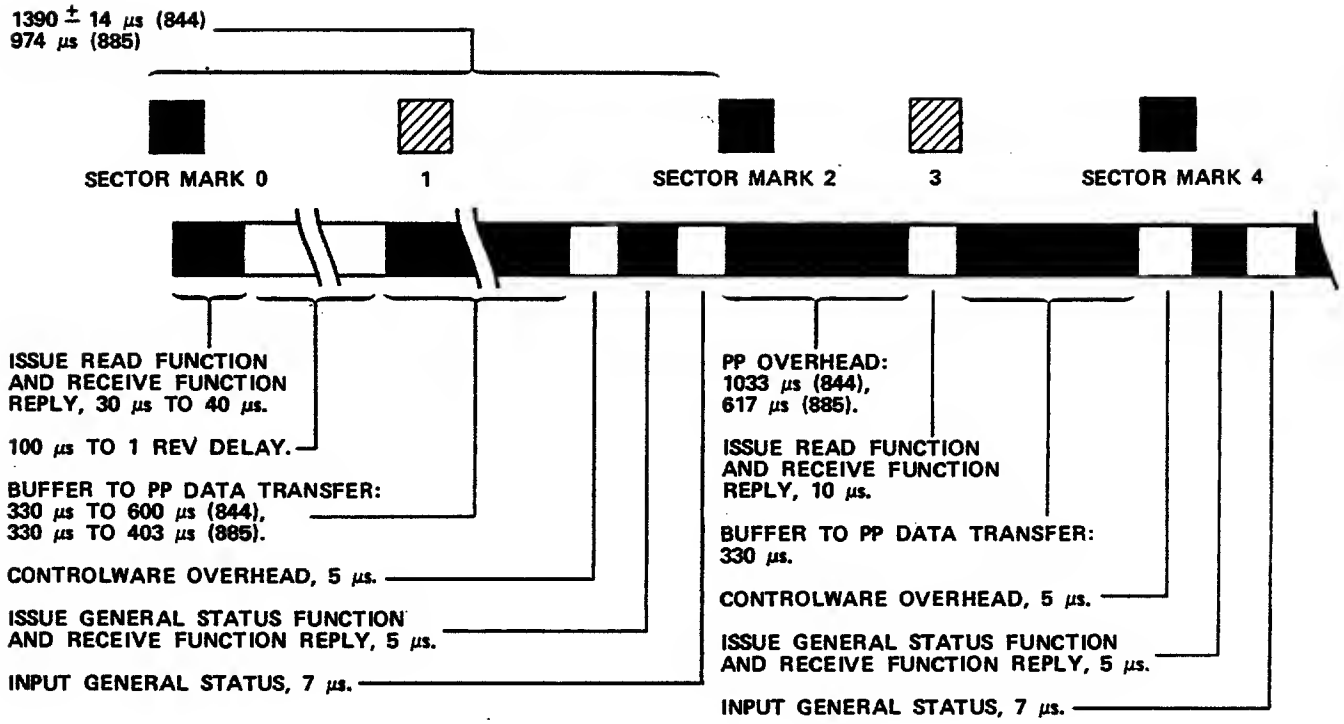


Figure B-3. 2:1 Interlace Read (1-MHz PP)

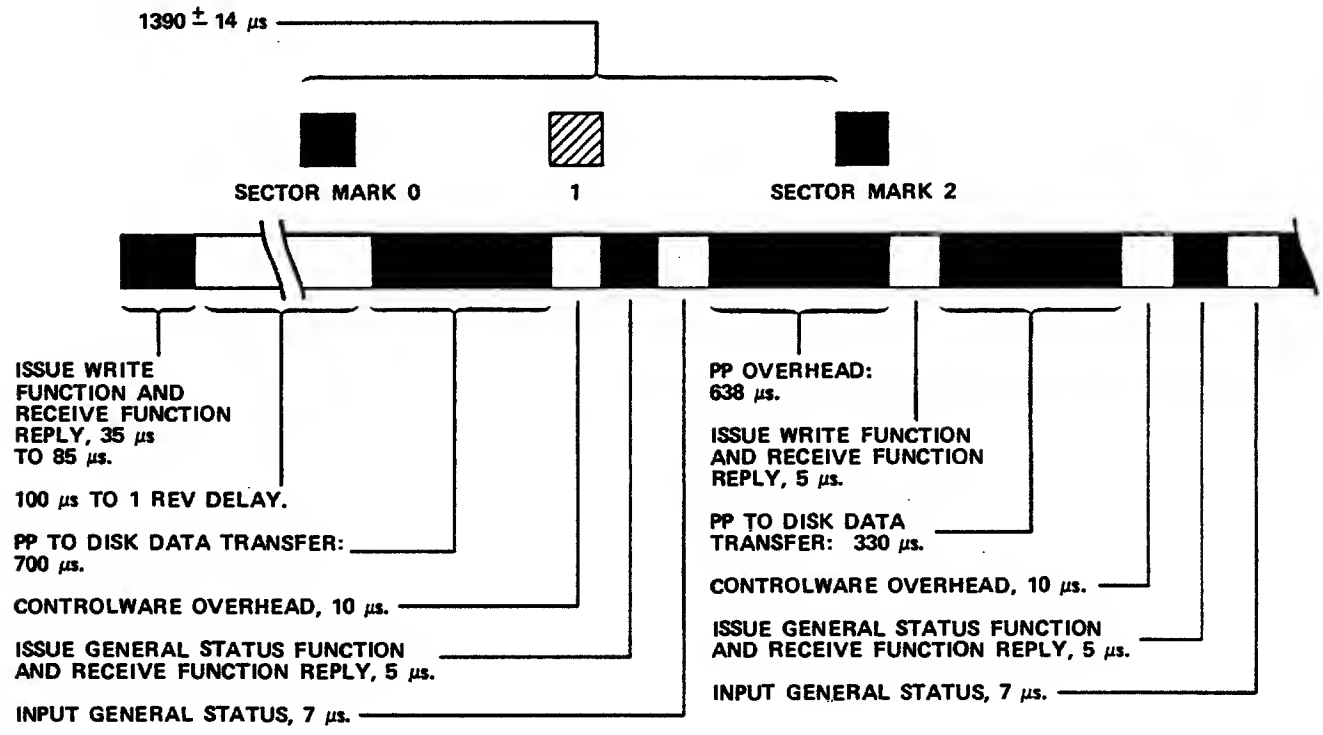


Figure B-4. 844 2:1 Interlace Write (1-MHz PP)

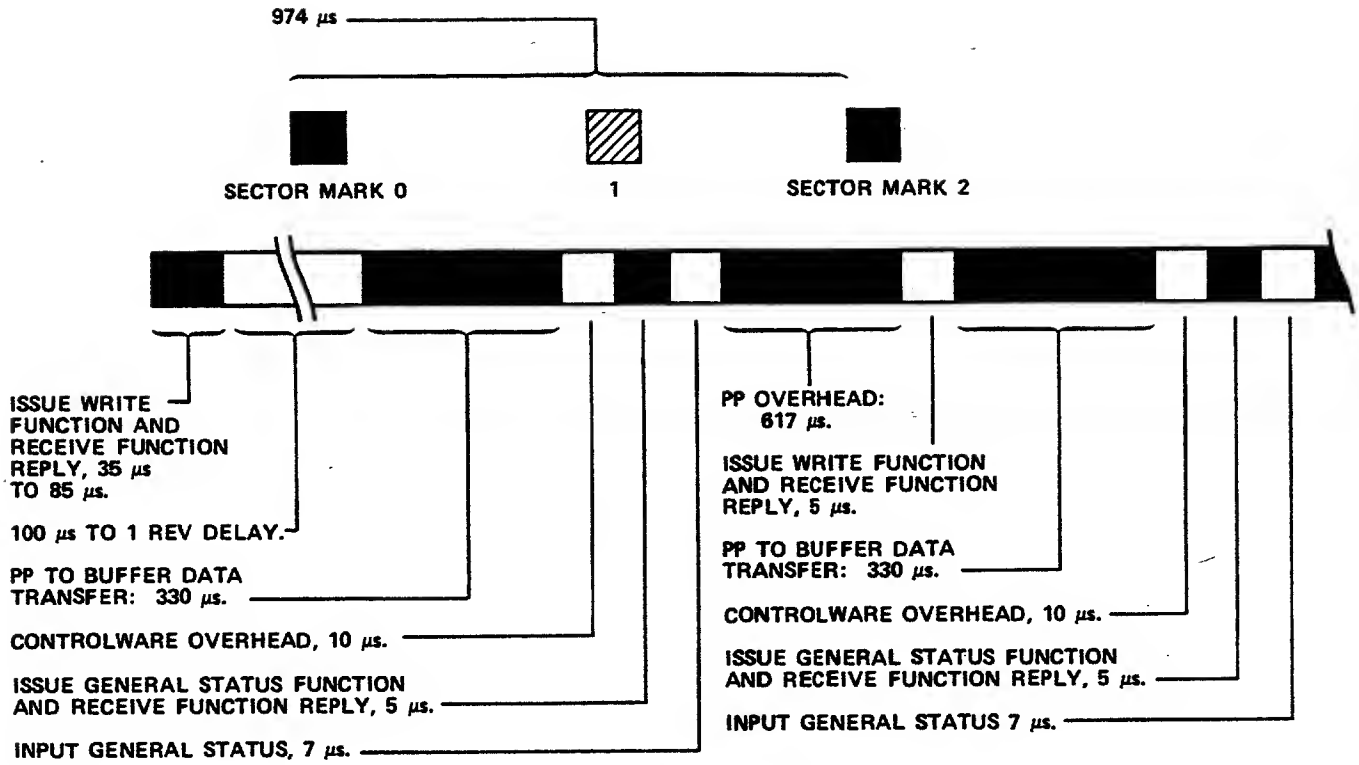


Figure B-5. 885 2:1 Interlace Write (1-MHz PP)

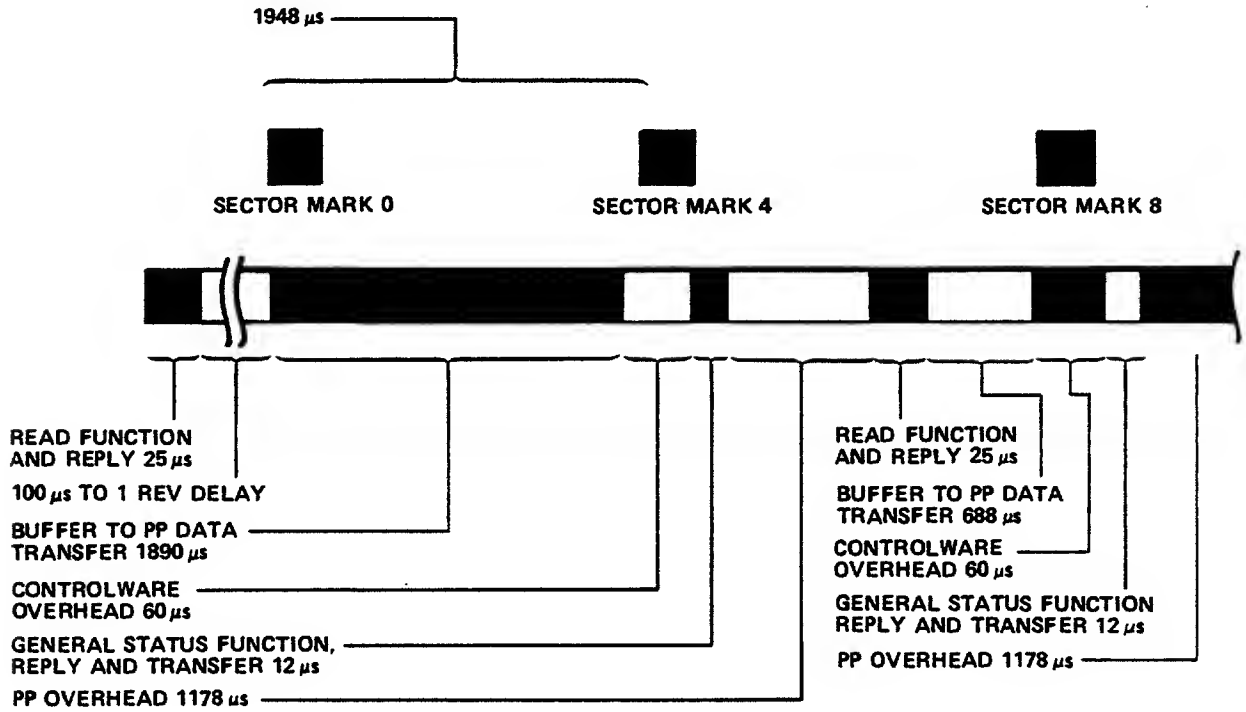


Figure B-6. 885-1X Large Sector Read

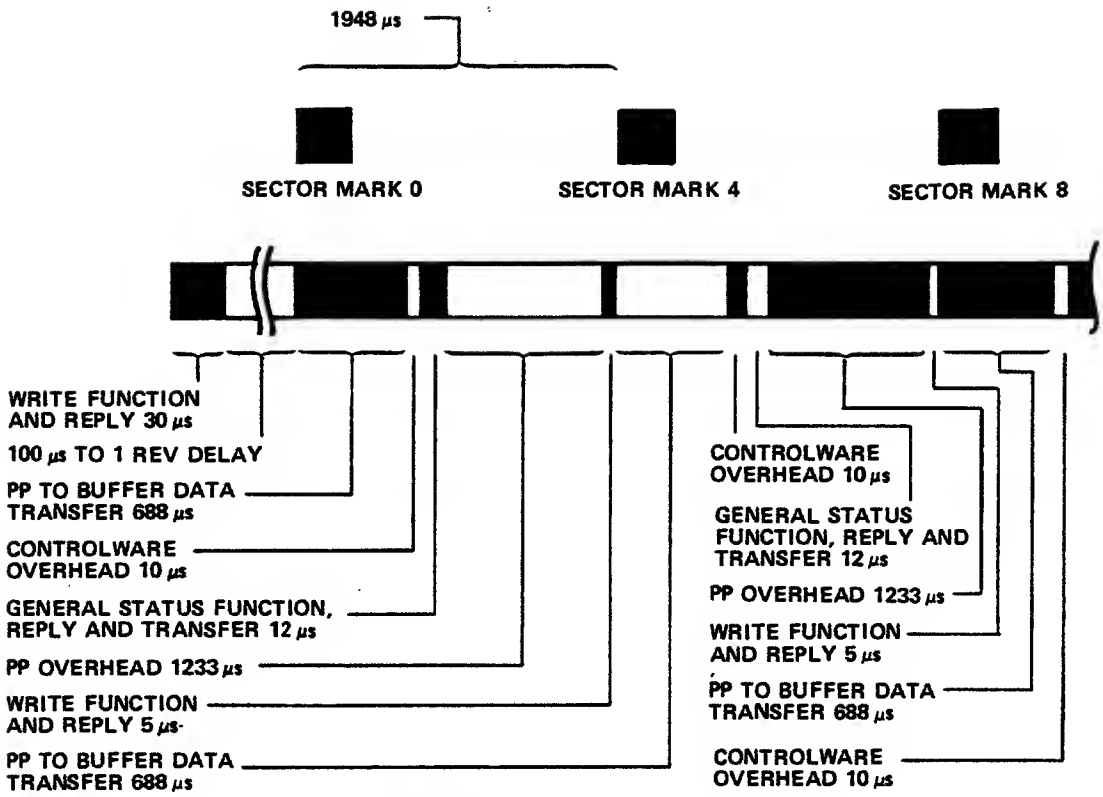


Figure B-7. 885-1X Large Sector Write

Tables C-1 through C-5 correlate general status and detailed status with conditions occurring during various types of operations. Refer to tables 3-2 and 3-3 and figure 3-2 for status bit descriptions. Interpret the status summaries in this appendix as follows:

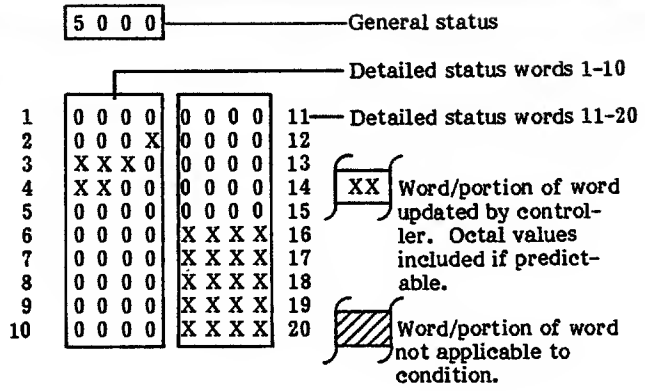


TABLE C-1. CONNECT/SEEK STATUS

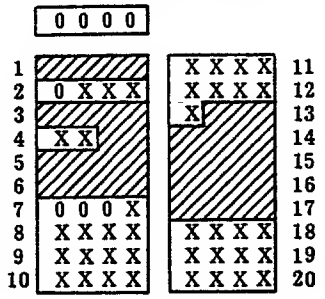
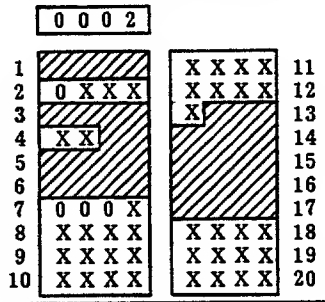
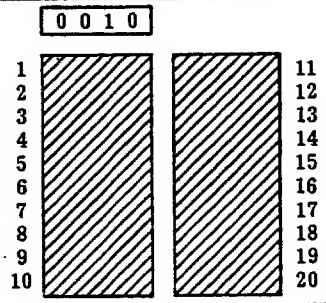
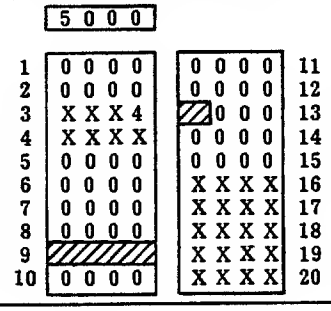
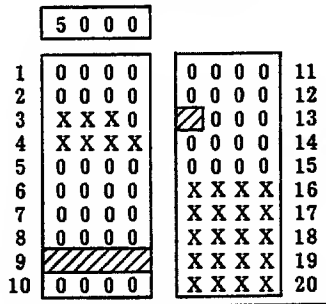
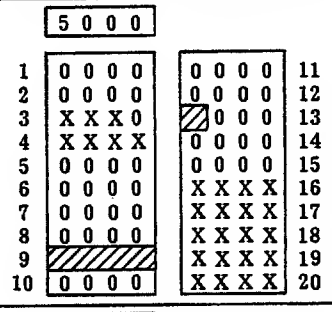
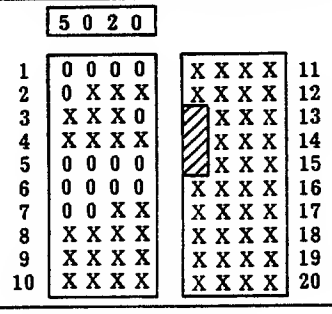
Condition	Status Summary
1. Drive online, ready, selected, and on-cylinder.	
2. Drive online, ready, selected; heads in motion.	
3. Drive reserved to other controller.	
4. Controller received function but did not receive all parameters.	
5. Controller received illegal cylinder, head, or sector parameter.	
6. Controller detected channel parity error during parameter transfer.	
7. Drive offline, drive not selected, drive not ready, seek error, or drive fault.	
8. Processor memory parity error (processor stops).	No status returned.
9. Channel parity error during status function transfer (controller does not reply to function).	No status returned.

TABLE C-2. READ/WRITE STATUS

Condition	Status Summary
1. Recoverable address field sync byte error during read, write, or read checkword function.	4 4 0 0 1 X X X 0 X X X X 11 2 0 X X X X X X X 12 3 X X X 0 X 0 0 0 13 4 X X X X 0 0 0 0 14 5 X X X X 0 0 0 0 15 6 X X X X X X X X 16 7 X X X X X X X X 17 8 X X X X X X X X 18 9 X X X X X X X X 19 10 X X X X X X X X 20
2. Nonrecoverable address field sync byte error during write function.	5 0 0 0 1 0 1 0 0 X X X X 11 2 0 X X X X X X X 12 3 X X X 0 X 0 0 0 13 4 X X X X 0 0 0 0 14 5 X X X X 0 0 0 0 15 6 X X X X X X X X 16 7 X X X X X X X X 17 8 X X X X X X X X 18 9 X X X X X X X X 19 10 X X X X X X X X 20
3. Nonrecoverable address sync byte error during write verify function.	5 0 0 0 1 0 0 2 0 X X X X 11 2 0 X X X X X X X 12 3 0 1 4 0 X 0 0 0 13 4 X X X X 0 0 0 0 14 5 X X X X 0 0 0 0 15 6 X X X X X X X X 16 7 X X X X X X X X 17 8 X X X X X X X X 18 9 X X X X X X X X 19 10 X X X X X X X X 20
4. Nonrecoverable address sync byte error during read or read checkword function.	5 0 0 0 1 0 7 0 0 X X X X 11 2 0 X X X X X X X 12 3 X X X 0 X 0 0 0 13 4 X X X X 0 0 0 0 14 5 X X X X 0 0 0 0 15 6 X X X X X X X X 16 7 X X X X X X X X 17 8 X X X X X X X X 18 9 X X X X X X X X 19 10 X X X X X X X X 20
5. Cylinder number miscompare during read, write, or read checkword function.	4 4 0 0 1 0 0 1 4 X X X X 11 2 0 X X X X X X X 12 3 X X X 0 X 0 0 0 13 4 X X X X 0 0 0 0 14 5 X X X X 0 0 0 0 15 6 X X X X X X X X 16 7 X X X X X X X X 17 8 X X X X X X X X 18 9 X X X X X X X X 19 10 X X X X X X X X 20
6. Nonrecoverable cylinder number miscompare during read, write, or read checkword function.	5 0 0 0 1 0 0 1 4 X X X X 11 2 0 X X X X X X X 12 3 X X X 0 X 0 0 0 13 4 X X X X 0 0 0 0 14 5 X X X X 0 0 0 0 15 6 X X X X X X X X 16 7 X X X X X X X X 17 8 X X X X X X X X 18 9 X X X X X X X X 19 10 X X X X X X X X 20
7. Cylinder number miscompare during write verify function.	5 0 0 0 1 0 0 1 4 X X X X 11 2 0 X X X X X X X 12 3 X X X 0 X 0 0 0 13 4 X X X X 0 0 0 0 14 5 X X X X 0 0 0 0 15 6 X X X X X X X X 16 7 X X X X X X X X 17 8 X X X X X X X X 18 9 X X X X X X X X 19 10 X X X X X X X X 20
8. Track number miscompare during read, write, or read checkword function.	4 4 0 0 1 0 0 1 2 X X X X 11 2 0 X X X X X X X 12 3 X X X 0 X 0 0 0 13 4 X X X X 0 0 0 0 14 5 X X X X 0 0 0 0 15 6 X X X X X X X X 16 7 X X X X X X X X 17 8 X X X X X X X X 18 9 X X X X X X X X 19 10 X X X X X X X X 20
9. Nonrecoverable track number miscompare during read, write, or read checkword function.	5 0 0 0 1 0 0 1 2 X X X X 11 2 0 X X X X X X X 12 3 X X X 0 X 0 0 0 13 4 X X X X 0 0 0 0 14 5 X X X X 0 0 0 0 15 6 X X X X X X X X 16 7 X X X X X X X X 17 8 X X X X X X X X 18 9 X X X X X X X X 19 10 X X X X X X X X 20
10. Sector number miscompare during read, write, or read checkword function.	4 4 0 0 1 0 0 1 1 X X X X 11 2 0 X X X X X X X 12 3 X X X 0 X 0 0 0 13 4 X X X X 0 0 0 0 14 5 X X X X 0 0 0 0 15 6 X X X X X X X X 16 7 X X X X X X X X 17 8 X X X X X X X X 18 9 X X X X X X X X 19 10 X X X X X X X X 20

TABLE C-2. READ/WRITE STATUS (Contd)

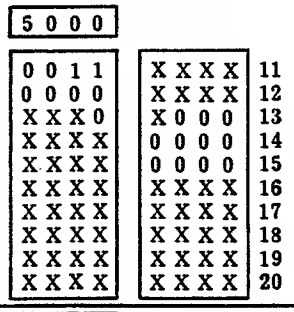
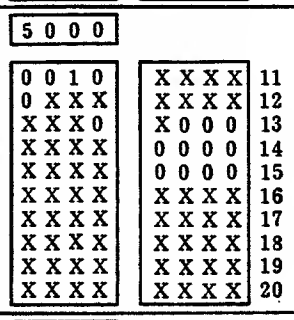
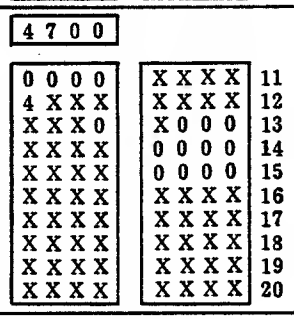
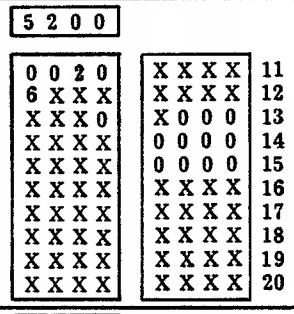
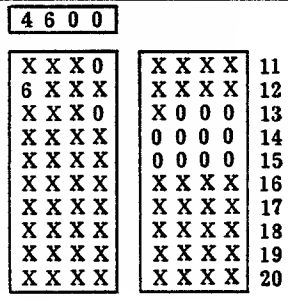
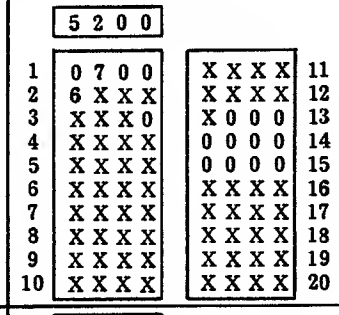
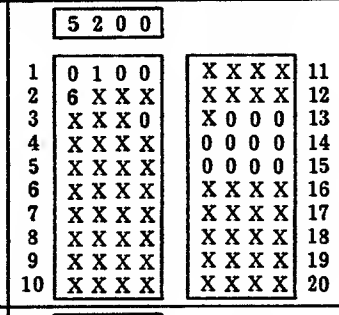
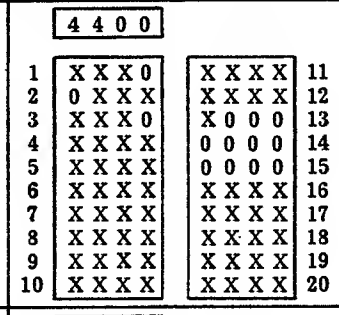
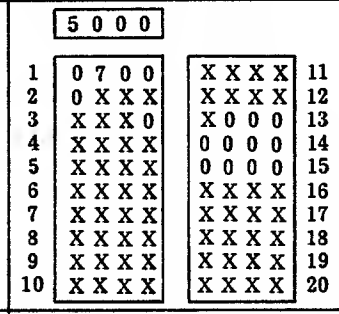
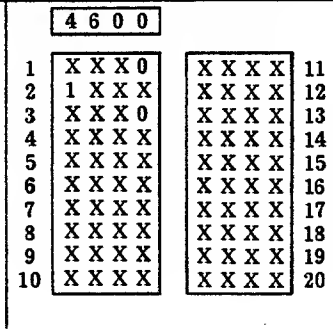
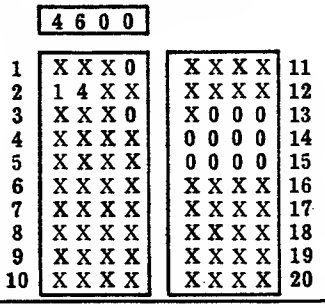
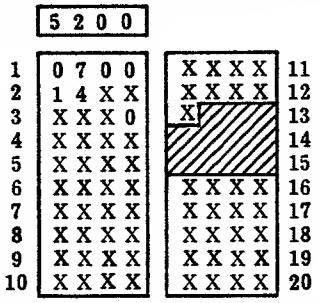
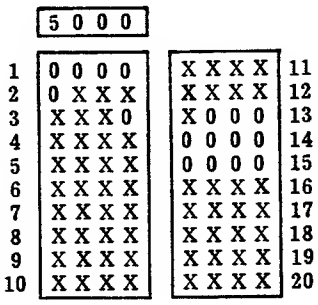
Condition	Status Summary
11. Nonrecoverable sector number miscompare during read, write, or read checkword function.	
12. Sector flaw or track flaw bit set in addressed sector (does not apply to read/write protected sector functions).	
13. Correctable address checkword error during read, write, or read checkword function.	
14. Address checkword error during write verify function.	
15. Address checkword error during read, write, or read checkword function.	
16. Nonrecoverable address checkword error during read or read checkword function.	
17. Nonrecoverable address checkword error during write function.	
18. Data field sync byte error during read or read checkword function.	
19. Nonrecoverable data field sync byte error during read or read checkword function.	
20. Correctable data field checkword error during read or read checkword function.	

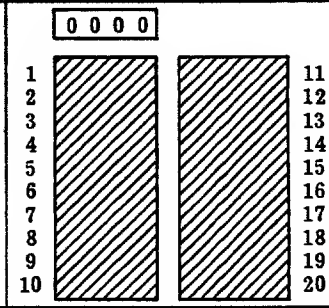
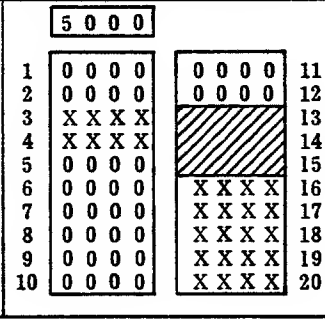
TABLE C-2. READ/WRITE STATUS (Contd)

Condition	Status Summary
21. Noncorrectable data field checkword error during read or read checkword function.	
22. Nonrecoverable data field checkword error during read or read checkword function.	

Condition	Status Summary
23. Controller status error, lost control word error, or sector length violation † during read, write, read checkword, or write verify function. 24. Lost data† during read or write function. 25. Data field compare error † during write verify function.	

† For write or write verify function, status summary shows status returned after function timeout.

TABLE C-3. SELECT STROBE AND OFFSET/BUFFER WRITE STATUS

Condition	Status Summary
1. Function completed without error.	
2. Controller did not receive parameters.	

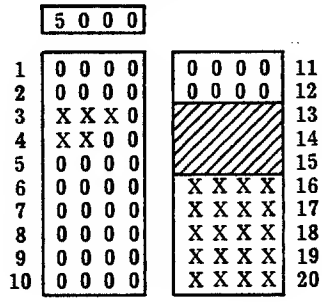
Condition	Status Summary
3. Channel parity error during parameter transfer.	

TABLE C-4. FORMAT PACK STATUS

Condition	Status Summary
1. Function completed without error.	0 0 0 0 1 2 3 4 5 6 7 8 9 10 — 11 12 13 14 15 16 17 18 19 20
2. Drive reserved to other controller.	0 0 1 0 1 2 3 4 5 6 7 8 9 10 — 11 12 13 14 15 16 17 18 19 20
3. Drive offline, drive not selected, drive not ready, seek error, or drive fault.	5 0 2 0 1 0 0 0 0 — 11 X X X X 2 0 X X X — 12 X X X X 3 0 3 4 0 — 13 0 0 0 0 4 X X X X — 14 0 0 0 0 5 0 0 0 0 — 15 0 0 0 0 6 0 0 0 0 — 16 X X X X 7 0 0 0 X — 17 X X X X 8 X X X X — 18 X X X X 9 X X X X — 19 X X X X 10 X X X X — 20 X X X X
4. Controller status error.	5 0 0 0 1 0 0 0 0 — 11 X X X X 2 0 X X X — 12 X X X X 3 0 3 4 0 — 13 0 0 0 0 4 X X X X — 14 0 0 0 0 5 X X X X — 15 0 0 0 0 6 X X X X — 16 X X X X 7 X X X X — 17 X X X X 8 X X X X — 18 X X X X 9 X X X X — 19 X X X X 10 X X X X — 20 X X X X
5. Subsystem busy processing function.	0 0 0 2 1 2 3 4 5 6 7 8 9 10 — 11 12 13 14 15 16 17 18 19 20
6. Illegal starting/ending disk address parameter.	5 0 0 0 1 0 0 0 0 — 11 0 0 0 0 2 0 0 0 0 — 12 0 0 0 0 3 0 3 5 0 — 13 0 0 0 0 4 X X X X — 14 0 0 0 0 5 0 0 0 0 — 15 0 0 0 0 6 0 0 0 0 — 16 0 0 0 0 7 0 0 0 0 — 17 0 0 0 0 8 0 0 0 0 — 18 X X X X 9 0 0 0 0 — 19 X X X X 10 0 0 0 0 — 20 X X X X
7. Utility map not readable.	Status is identical to that listed in table C-2 for read functions, except all general status is 5XXX (nonrecoverable).
8. Drive fault during formatting.	5 0 X 0 1 0 0 0 0 — 11 X X X X 2 0 X X X — 12 X X X X 3 0 3 4 0 — 13 0 0 0 0 4 X X X X — 14 0 0 0 0 5 X X X X — 15 0 0 0 0 6 X X X X — 16 X X X X 7 X X X X — 17 X X X X 8 X X X X — 18 X X X X 9 X X X X — 19 X X X X 10 X X X X — 20 X X X X
9. 844 drive only. Sector or track flaw condition detected during formatting. Detailed status contains disk address.	4 4 0 0 1 0 0 0 0 — 11 0 0 0 0 2 0 0 0 0 — 12 0 0 0 0 3 0 3 4 0 — 13 0 0 0 0 4 X X X X — 14 0 0 0 0 5 X X X X — 15 0 0 0 0 6 X X X X — 16 0 0 0 0 7 0 0 0 0 — 17 0 0 0 0 8 0 0 0 0 — 18 X X X X 9 0 0 0 0 — 19 X X X X 10 0 0 0 0 — 20 X X X X

TABLE C-5. SET/CLEAR FLAW STATUS

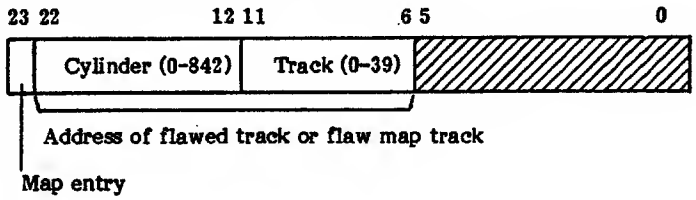
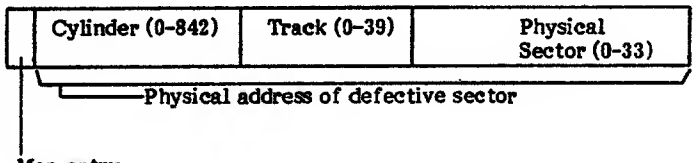
Condition	Status Summary
1. Function completed without error.	0 0 0 0 1 2 3 4 5 6 7 8 9 10 — 11 12 13 14 15 16 17 18 19 20
2. Channel parity error during parameter transfer.	5 0 0 0 1: 0 0 0 0 — 11: 0 0 0 0 2: 0 0 0 0 — 12: 0 0 0 0 3: X X X 4 — 13: 0 0 0 0 4: X X 0 0 — 14: 0 0 0 0 5: 0 0 0 0 — 15: 0 0 0 0 6: 0 0 0 0 — 16: X X X X 7: 0 0 0 0 — 17: X X X X 8: 0 0 0 0 — 18: X X X X 9: — 19: X X X X 10: 0 0 0 0 — 20: X X X X
3. Utility map not readable.	Status is identical to that listed in table C-2 for read functions, except all general status is 5XXX (nonrecoverable).
4. Illegal operation (attempting to set/clear sector flaw bit in flawed track).	5 0 0 0 1: 0 0 0 0 — 11: 0 0 0 0 2: 0 0 0 0 — 12: 0 0 0 0 3: 0 X X 0 — 13: 0 0 0 0 4: X X X X — 14: 0 0 0 0 5: 0 0 0 0 — 15: 0 0 0 0 6: 0 0 0 0 — 16: 0 0 0 0 7: 0 0 0 0 — 17: 0 0 0 0 8: 0 0 0 0 — 18: X X X X 9: 0 0 0 0 — 19: X X X X 10: 0 0 0 0 — 20: X X X X
5. Subsystem busy processing function.	0 0 0 2 1 2 3 4 5 6 7 8 9 10 — 11 12 13 14 15 16 17 18 19 20
6. Controller status error.	5 0 0 0 1: 0 0 0 0 — 11: X X X X 2: 0 0 0 0 — 12: X X X X 3: 0 4 4 0 — 13: 0 0 0 0 4: X X X X — 14: 0 0 0 0 5: X X X X — 15: 0 0 0 0 6: X X X X — 16: X X X X 7: X X X X — 17: X X X X 8: X X X X — 18: X X X X 9: X X X X — 19: X X X X 10: X X X X — 20: X X X X
7. Drive fault.	5 0 X 0 1: 0 0 0 0 — 11: X X X X 2: 0 0 0 0 — 12: X X X X 3: 0 4 4 0 — 13: 0 0 0 0 4: X X X X — 14: 0 0 0 0 5: X X X X — 15: 0 0 0 0 6: X X X X — 16: X X X X 7: 0 0 0 0 — 17: X X X X 8: 0 0 0 0 — 18: X X X X 9: X X X X — 19: X X X X 10: X X X X — 20: X X X X

Table D-1 provides disk addresses and entry formats for 844/885 factory and utility data areas.

TABLE D-1. PACK DATA AREAS

Pack Data Area	Disk Address			Number of Entries	Entry Format
	Cylinder	Track	Sector(s)		
844 factory-recorded manufacturing data	822	0	0	1	47 24 23 0 Pack serial number Date of pack manufacture Example: 016852 0000 0001 0110 1000 0101 0010 Example: 28 Feb. 77 0010 1000 0000 0010 0111 0111
844 factory map	822	0	1	0-160	23 22 21 12 11 6 5 0 Cylinder (0-822) | Track (0-18) | Sector (0-23) 0 1 Track flaw entry 1 0 Sector flaw entry Address of flawed sector/track NOTE Zero-filled 24-bit entry follows last map entry. Example: Sector flaw, cylinder 409, track 3, sector 10 10 0110011001 000011 001010
844 utility map	822	0	2	0-160	Entry format is identical to entry format for 844 factory map. 844 utility map is comprehensive flaw map and contains all 844 factory map entries plus all flaw entries set by 0022 (set/clear flaw) function.

TABLE D-1. PACK DATA AREAS (Contd)

Pack Data Area	Disk Address			Number of Entries	Entry Format
	Cylinder	Track	Sector(s)		
885 factory-recorded manufacturing data	841	0	0	1	Entry format is identical to entry format for 844 factory-recorded manufacturing data.
885 factory track flaw map	841	0	1	1-120	 NOTES 1. PP must not modify 885 factory track flaw map. Refer to 885 utility map. 2. All map entries must be contiguous. First entry with bit 23 clear indicates previous entry was last valid entry. Example: Cylinder 841, track 21 1011 0100 1001 0101 0100 0000
885 factory defective sectors map	841	0	2-18	0-2040	 NOTES 1. Each map sector contains a maximum of 120 entries. 2. PP must not modify 885 factory defective sectors map. Refer to 885 utility map. 3. All map entries must be contiguous. First entry with bit 23 clear indicates previous entry was last valid entry. Example: Cylinder 120, track 21, sector 33 1000 0111 1000 0110 1010 0001
885 utility map	841	1	0-18	2-2161	When pack leaves factory, 885 utility map is exact copy of cylinder 841, track 0, sectors 0-18. PP should enter track flaws/defective sectors in 885 utility map and never modify 885 factory track flaw map or 885 factory defective sectors map.

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